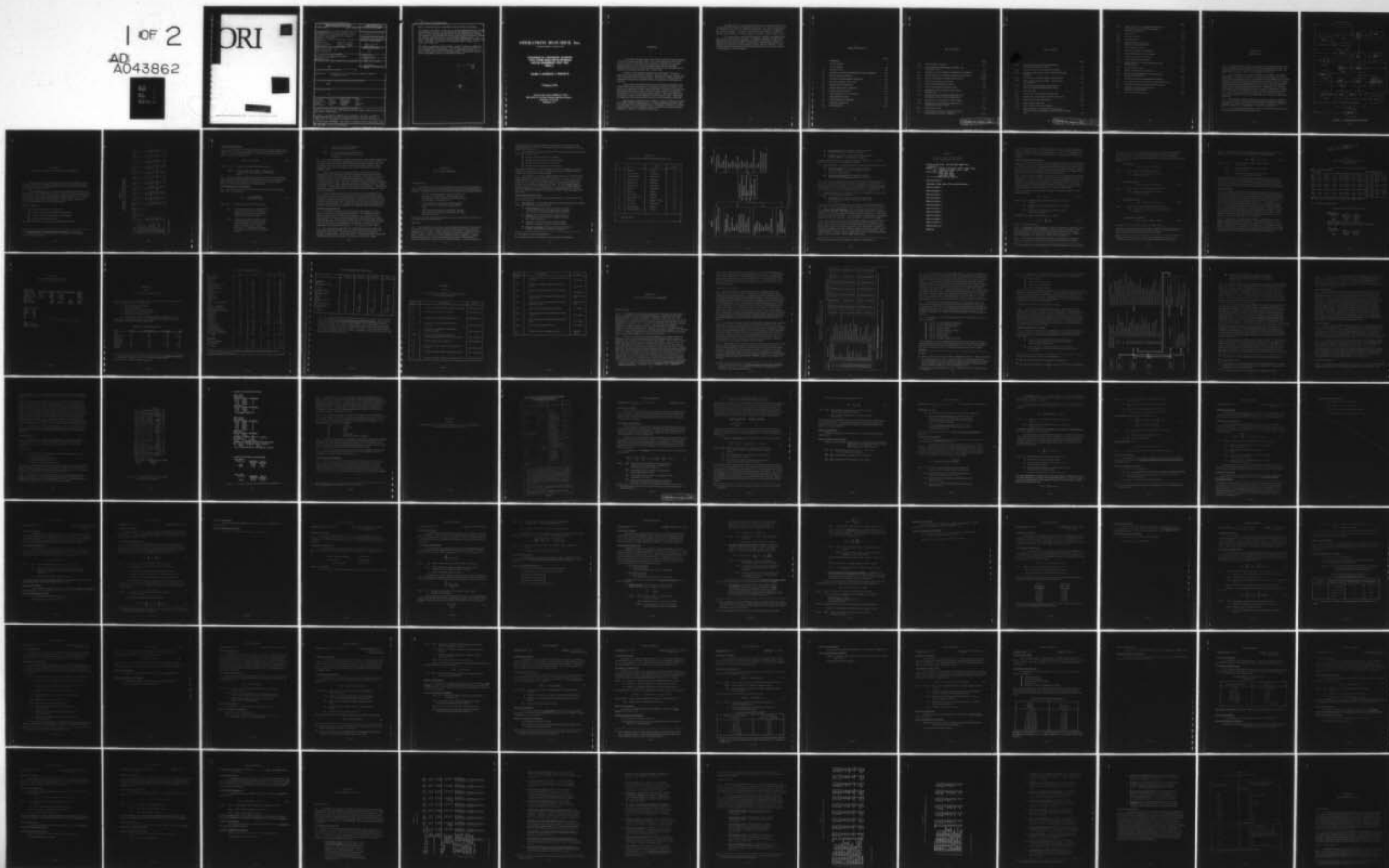
AD-A043 862 OPERATIONS RESEARCH INC SILVER SPRING MD F/G 5/1
DEVELOPMENT OF A PRELIMINARY AUTOMATED TOTAL SYSTEMS MODEL FOR --ETC(U)
FEB 70 T N KYLE, R D HEILBRON, J D AVILA N00025-67-C-0031
UNCLASSIFIED ORI-TR-583-VOL-2 NL

1 OF 2
AD
A043862



AD A043862

ORI

1

Operations Research, Inc. A Subsidiary of Leasco Systems Corporation

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Development of a Preliminary Automated Total Systems Model for the Integrated Facilities Requirements study (IFRS) Phase II, Volume II - Appendices A through M.	5. TYPE OF REPORT & PERIOD COVERED Final Report of 9 Feb '70
	6. PERFORMING ORG. REPORT NUMBER ORI TR; NO. 583, VOL II of IV
7. AUTHOR(s) Thomas N. Kyle, Richard D. Heilbron, John D. Avila, Frederick L. McCoy, Thomas L. Shaffer, Dr. Joan L. Turek	8. CONTRACT OR GRANT NUMBER(s) N00025-67-C-0031 (NBY)-78672
9. PERFORMING ORGANIZATION NAME AND ADDRESS Operations Research, Inc. Silver Spring, MD	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N.A.
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command Department of the Navy Washington, DC	12. REPORT DATE 9 February 1970
	13. NUMBER OF PAGES 180
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) SAME	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Statement No. 1 - Distribution of this Document is unlimited; approved for public release.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

SAME

18. SUPPLEMENTARY NOTES

N.A.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Facilities	Fleet	Simulation	Static
Requirements	Training	Programming	Air
Dynamic	Aircraft	Management	Readiness
Optimization	Pilot	Planning	Model

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the second phase of the multi-phase integrated Facilities Requirements Study (IFRS).

In Phase I, two analytic submodels were developed. The first, a Logistics Support Requirements Generator, estimates personnel, aircraft, and fuel requirements for each phase of undergraduate pilot training at the Naval Air Training Command (NATRACOM). The second, a Pacing Facilities Requirements sub-

model, calculates facility requirements for each phase of training.

The purpose of the Phase II study was to develop a preliminary total systems IFRS management planning tool (including the two submodels developed in Phase I, as well as Base Loading, Facilities Excess/Deficiency, and Total Cost submodels), and automate the model so that it provides quick, accurate, and relevant information for use in the decision-making process. The present IRFS model is working to provide useful information to the decision-maker. Refinement and expansion of the present Phase II model will be completed in Phase III.

This report is composed of four volumes. Volume I contains a summary of the IFRS management planning tool. A detailed discussion of each of the five submodels and associated data files is contained in Volume II. A manual discussing the use of the automated model is provided in Volume III and the programmer's manual is contained in Volume IV.

OPERATIONS RESEARCH, Inc.
SILVER SPRING, MARYLAND

DEVELOPMENT OF A PRELIMINARY AUTOMATED TOTAL SYSTEMS MODEL FOR THE INTEGRATED FACILITIES REQUIREMENTS STUDY (IFRS) PHASE II

VOLUME II—APPENDICES A THROUGH M

9 February 1970

Prepared under Contract N00025-67-C-0031
(NBy-78672) for the Naval Facilities Engineering Command
Department of the Navy
Washington, D.C.

FOREWORD

This report documents the second phase of the multi-phase Integrated Facilities Requirements Study (IFRS). It has been prepared for the Systems Analysis Division of the Office of the Assistant Commander for Facilities Planning (Code 20), Naval Facilities Engineering Command (NAVFAC), Department of the Navy, as part of Contract N00025-67-C-0031 (NBy-78672) awarded to Operations Research, Inc., in June 1969.

In Phase I, two analytic submodels were developed. The first, a Logistics Support Requirements Generator, estimates personnel, aircraft, and fuel requirements for each training phase. The second, a Pacing Facilities Requirements Submodel, calculates facility requirements for each phase of training.

The purpose of the Phase II study was to develop a preliminary total systems IFRS model (including the two submodels developed in Phase I, as well as base loading, facilities excess/deficiency, and total cost submodels), and automate the model so that it provides quick, accurate, and relevant information for use in the decision-making process. The present IFRS model is working to provide useful information to the decision maker. Refinement and expansion of the present Phase II model will be completed in Phase III.

This report is composed of four volumes. Volume I contains a summary of the IFRS management planning tool. A detailed discussion of each of the five submodels and associated data files is contained in Volume II. A manual discussing the use of the automated model is provided in Volume III and the programmer's manual is contained in Volume IV.

The IFRS model was developed and programmed by staff members of the Economic Analysis Division of Operations Research, Inc., under the direction of Dr. William J. Leininger, Vice President and Division Director, and Thomas N. Kyle, Project Manager. The project team members were Richard D. Heilbron, John H. Avila, Frederick L. McCoy, Thomas L. Shaffer, and Dr. Joan L. Turek.

Mr. Dennis Whang of the Systems Analysis Division of Facilities Planning was contract monitor for NAVFAC. In addition, valuable assistance was provided by many other Navy personnel including, in particular, those in the Office of the Staff Civil Engineer and the Training/Plans Division of the Naval Air Training Command and in the Systems Analysis Division of NAVFAC. The authors gratefully acknowledge the contributions made by all of these people to the development of the IFRS model.

TABLE OF CONTENTS

		Page
	FOREWORD	i
	LIST OF FIGURES	v
	LIST OF TABLES	vii
A.	INTRODUCTION	A-1
B.	LOGISTICS SUPPORT REQUIREMENTS (LSR) GENERATOR	B-1
C.	BASE LOADING SUBMODEL	C-1
D.	FACILITIES REQUIREMENTS SUBMODEL	D-1
E.	BASE AND AIRCRAFT DATA FILES	E-1
F.	ASSET POSITION DATA FILE	F-1
G.	EXCESS/DEFICIENCY SUBMODEL	G-1
H.	RUNWAY METHODOLOGY	H-1
I.	TOTAL SYSTEMS COST SUBMODEL	I-1
J.	PERFORMANCE MODEL	J-1
K.	QUANTIFICATION PROBLEMS	K-1
L.	SENSITIVITY ANALYSIS	L-1
M.	BIBLIOGRAPHY	M-1

LIST OF FIGURES

		Page
A.1.	IFRS Simulation Concept	A-2
C.1.	Base Loading Submodel Inputs, Outputs, and Component Parts	C-4
D.1.	Overview of Base Facilities Requirements Calculations	D-6
D.2.	Sample Printout of Facilities Requirements Submodel	D-10
D.3.	Runway and Special Facilities Requirements	D-11
I.1.	TSC Submodel Inputs and Outputs	I-4
I.2.	Size/Unit Cost Adjustment Chart	I-10
K.1.	Uneven Distribution of Sample Points	K-4
L.1.	Sensitivity of Total Systems Cost to Pilot Training Rate	L-3
L.2.	Sensitivity of Investment and Operating and Maintenance Costs to Pilot Training Rate	L-4
L.3.	Sensitivity of Total Systems Cost to Mode	L-6
L.4.	Sensitivity of Investment and Operating and Maintenance Costs to Mode	L-7
L.5.	Sensitivity to Mix	L-9
L.6.	Total Systems Cost as a Function of Phase Assignment and Facility Condition	L-11

LIST OF TABLES

		Page
B.1.	Data Base for the LSR Generator (Current Pilot Training Planning Factors)	B-2
C.1.	Current Phase to Base Assignment Schedule	C-3
C.2.	Decision Maker Input of Phase to Base Assignment Schedule	C-6
C.3.	Base Loading Submodel Output: Summary Data	C-10
C.4.	Base Loading Submodel Output: Detailed Data, NAS Meridian	C-11
D.1.	IFRS Facility Requirements List, Including Percent of Total Base Replacement Cost	D-3
E.1.	Base Data File	E-2
E.2.	Aircraft Data File—Training Aircraft Data	E-6
E.3.	Aircraft Data File—Tenant and NAS Aircraft Data	E-7
E.4.	Alternative Aircraft Designations	E-10
F.1.	Asset Position Data File	F-2
F.2.	Asset Position Data File—Runways	F-3
G.1.	Sample Printout of Facilities Requirements and Excess/Deficiency Submodels Using Standard Facilities Only	G-3

		Page
G.2.	Sample Printout of Facilities Requirements and Excess/Deficiency Submodels Accepting Substandard Facilities	G-4
H.1.	Runway Data	H-3
H.2.	Available Runways	H-4
H.3.	Required Runways	H-4
H.4.	Airfield Pavement Costs as a Function of Thickness Factor	H-17
H.5.	IFRS Thickness Factor	H-19
I.1.	IFRS Total Systems Cost Elements	I-3
I.2.	Sample Total Systems Cost Printouts	I-5
I.3.	Facility Investment CER Factors	I-11
I.4.	Ready Fuel Storage Tank Sizes	I-12
I.5.	Sample Printout of Facility Investment Costs, NAS Meridian	I-14
I.6.	Aircraft Flyaway Costs	I-15
I.7.	Facility Maintenance Cost Factors	I-22
I.8.	Sample Detailed Operations and Maintenance Printout, NAS Meridian.	I-25
J.1.	Possible Interaction of Independent Variables	J-4
J.2.	How Independent Variables Might Affect Performance . . .	J-5
K.1.	Dependent Variables and Estimators (Personnel)	K-3
K.2.	Dependent Variables and Estimators (Facilities Requirements)	K-6
L.1.	Sensitivity Analysis Summary.	L-15

APPENDIX A

INTRODUCTION

A.1 The purpose of this volume is to provide an in-depth discussion of the component parts of the Integrated Facilities Requirements (IFRS) model. The overall relationship of the submodels and data files programmed in the IFRS model was discussed in Volume I and is shown in Figure A.1.

A.2 Each submodel is discussed separately in this volume, with inputs, methodology, and outputs described. The runway methodology developed is also discussed separately herein, even though it is not identified as a separate submodel. Several data files are incorporated in the model. The use of data files permits the same planning factors to be accessed by different submodels without duplication and also allows the user to easily change the planning factors at the terminal without reprogramming. Furthermore, the data files are organized so that all data of the same category are included in a separate file. For instance, aircraft related data are contained in the Aircraft Data File, specific base data in the Base Data File, etc. These data files, as well as the submodels and runway methodology, are described in Appendices B through I.

A.3 The Performance Model developed by the Navy appears in Appendix J. A discussion of some of the quantification problems encountered appears in Appendix K. A discussion of the sensitivity analysis completed in Phase II appears in Appendix L; a bibliography is provided in Appendix M.

A.4 It is recommended that Volume I be studied initially and that Volume II be consulted when particular questions arise.

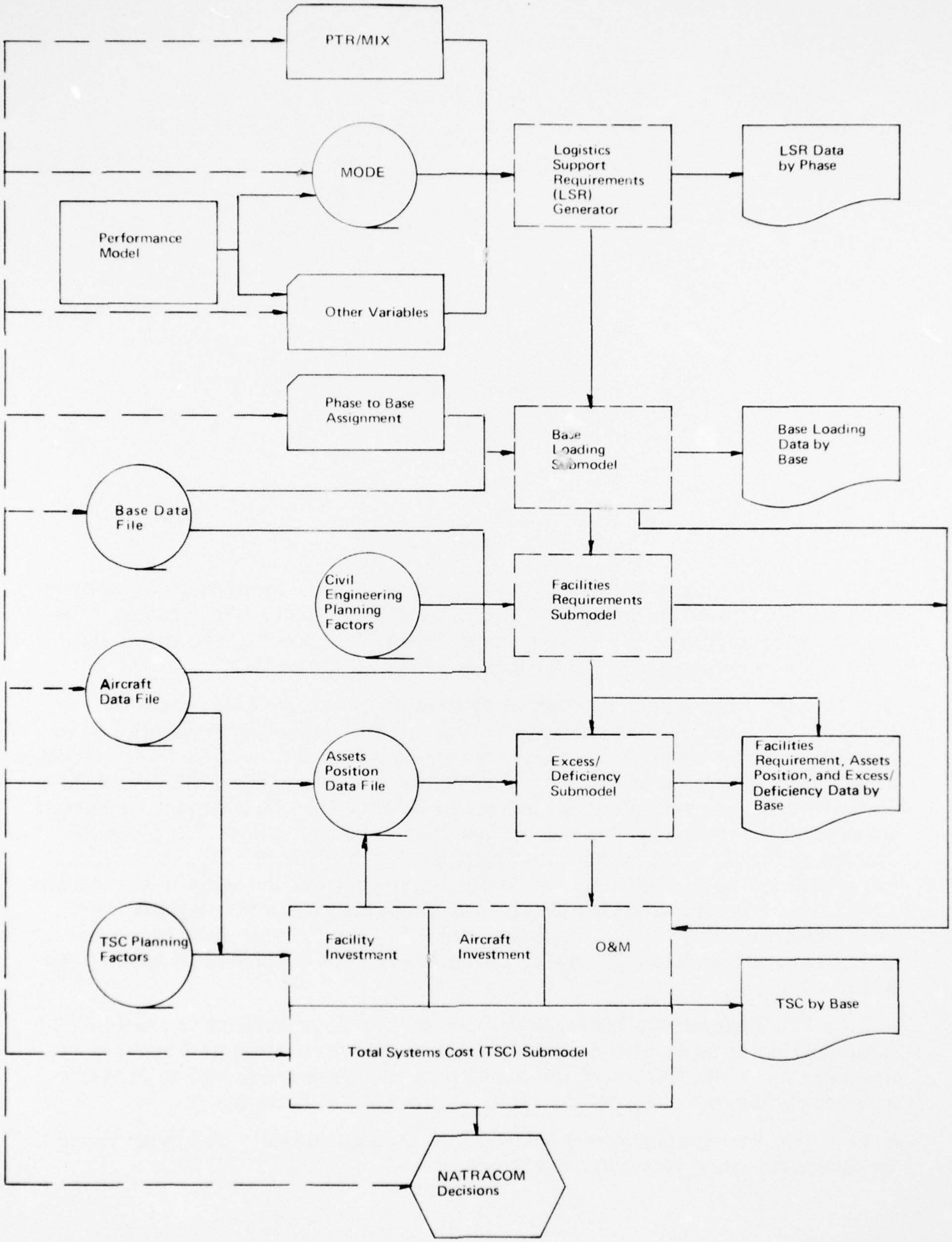


FIGURE A.1. IFRS SIMULATION CONCEPT

APPENDIX B

LOGISTICS SUPPORT REQUIREMENTS (LSR) GENERATOR

B.1 The purpose of the LSR Generator is to develop the personnel, aircraft, and bulk fuel required to support a particular PTR for each phase in the pilot training program. The basic methodology was developed in the Phase I study and automated in Phase II. 1/

B.2 While automating the LSR Generator minor methodological changes were made to provide the NATRACOM with a more accurate and flexible planning tool. The changes are discussed in this appendix. Also provided here, see Table B.1, is a list of the current pilot training planning factors which serve as the data base for all examples of the LSR Generator. Sample computer printouts of the LSR Generator appear in Volume I of this report.

PHASE II CHANGES

B.3 The Phase I methodology was changed by:

- Addition of landing support officer requirements
- Changes in aircraft requirements calculations
- Addition of multiple pipelines.

These modifications are discussed in the following paragraphs.

1/ See Integrated Facilities Requirements Study, Phase I, ORI TR 520, 5 December 1968, for a discussion of the development and methodology of the two-model system.

TABLE B.1

DATA BASE FOR THE LSR GENERATOR *
(Current Pilot Training Planning Factors)

Phase Name	Primary	AOC School	Flight System	Basic Jet-A	Basic Jet-B	B-Jet G/CQ	Adv Jet-TF	Adv Jet-TA	Basic Prop	B-Prop CQ	Adv Prop	Pre-Helo	Helo Primary	Helo Adv
Attrition point	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Phase duration, weeks	6	10	5	11	9	7	20	20	19	4	17	5	4	8
Tour of duty, months	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Aircraft types	1	0	0	1	1	1	1	1	1	1	1	1	1	1
Instruction types	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aircraft types	T34B			T-2A	T2BC	T2BC	TF9J	TA4J	T28C	T28C	TS2A	T28C	TH57	THIL
Fuel type	AGAS			JP-4	JP-4	JP-4	JP-4	JP-4	AGAS	AGAS	A115	AGAS	AGAS	JP-4
Flyable weather, %	78.2			80.5	79.5	83.0	84.6	85.0	77.6	87.9	86.5	85.0	83.6	86.4
Fuel consumption	12.60			311.00	365.00	365.00	575.00	470.00	50.50	50.50	96.60	50.50	12.60	100.00
Aircraft utilization	4.20			3.54	3.35	2.63	2.90	3.12	3.71	2.81	3.72	3.81	3.31	2.98
Instructor utilization	3.01			2.85	2.85	2.36	2.10	2.10	3.10	2.22	2.75	3.20	2.96	2.77
Flight hours	32.60			65.10	64.40	30.70	212.50	206.10	127.50	15.00	135.70	23.50	24.20	57.00
Flight instructor hours	29.20			67.00	53.70	20.90	145.30	143.30	98.70	6.60	119.90	23.60	24.40	59.80
Instructor training period	2.00			2.00	2.00	2.00	3.00	3.00	2.00	2.00	3.00	2.00	2.00	2.00
LSO ratio	0			0	0	15.00	0	0	0	10.00	0	0	0	0
Maintenance men	2.55			5.46	7.16	7.76	7.35	7.50	4.32	5.47	8.89	4.80	3.00	6.02

* December 1969.

Landing Support Officers

B.4 To account for the additional officers who are required for the aircraft carrier qualifications training phases, the category of landing support officers (LSO) was added to the LSR Generator. The LSO requirements for training phase i, LSO_i, are computed by:

$$LSO_i = SL_i \,/\, KLSO_i \tag{B.1}$$

where SL_i = average student load for training phase i

$KLSO_i$ = average number of students a single landing support office can support in the i^{th} training phase.

B.5 Since the landing support officers generally require less preparatory instruction than flight instructors prior to the time they are permitted to aid in the landing of student pilots, the required number of landing support officers is not increased to reflect a training period.

Aircraft Requirements Calculations

B.6 The number of aircraft of type t that are required in the i^{th} training phase (AC_i^t) is computed by

$$AC_i^t = \frac{(SO_i)\ (FH_i^t)}{(AU_i^t)\ (AFD)\ (WX_i^t)} \tag{B.2}$$

where SO_i = annual PTR for the i^{th} training phase

FH_i^t = average number of type t aircraft flight hours, both overhead and syllabus, required for a student to successfully complete the i^{th} training phase

AU_i^t = average daily number of hours an aircraft of type t may be utilized for the training of pilots in the i^{th} training phase assuming perfect weather prevails; i.e., no scheduled flights are delayed or canceled due to adverse weather

AFD	=	annual number of days which are scheduled for flight training
WX_i^t	=	percent of the annual weather which is flyable for aircraft type t in training phase i.

B.7 The above formulation of aircraft requirements differs from the formulation developed in the IFRS Phase I Final Report in two ways: (a) weather (WX_i^t) is developed with respect to the aircraft type within a training phase rather than being phase specific; and (b) annual aircraft utilization is computed (daily utilization times annual scheduled fly days) rather than entered as a single planning factor.

B.8 Should different types of flight instruction exist within a particular training phase, viz, flight and "in-flight" instrumentation, the prevailing weather may affect each instruction type differently. For example, instrument flight requires that a qualified instructor accompany the student pilot while he is flying on instruments. Since the instructor pilot is experienced in flying in adverse weather, a sortie might not be canceled when the weather is marginal. On the other hand, with the same marginal weather conditions, if a new student were flying, a normal sortie could be canceled due to the weather. Consequently, orienting the weather factor to the type of aircraft instruction results in a more flexible methodology.

B.9 Annual aircraft utilization rates are computed in the automated IFRS system as the product of daily utilization rates and the number of days which are annually scheduled for flight instruction. This permits the user to rapidly evaluate the consequences associated with an increase or decrease in the days scheduled for flight instruction. Note that if the IFRS Phase I methodology had been used without change, the aircraft utilization planning factors would have had to be revised to evaluate changes in the scheduled flight instruction days.

Multiple Training Pipelines

B.10 The NATRACOM draws student pilots from various sources: Navy, Marines, Coast Guard, and foreign governments. The student curriculum varies as a function of the source of the student, e.g., Marines are not trained in Advance Prop, Coast Guard personnel do not participate in carrier qualifications, etc. Also, historic attrition data indicate that phase attrition rates vary with respect to the source of the student. To enhance the accuracy of the LSR Generator, the methodology was changed to enable the user to incorporate several training pipelines, i.e., one for each student source.

B.11 The computational procedures for determining the student output and student input for each training phase are identical to those presented in the IFRS Phase I Final Report. The student inputs, outputs, and attrites are computed separately for each training pipeline, then aggregated over all phases. The remainder of the LSR Generator is presented in the Phase I Report.

APPENDIX C

BASE LOADING SUBMODEL

INTRODUCTION

C.1 The purpose of the Base Loading Submodel is to calculate total personnel and aircraft assignments and fuel consumption for each base in the pilot training program. The following functions are performed within the Base Loading Submodel.

a. The time-sharing operator assigns each phase of training to a specific base. On this basis, the training phase data calculated in the LSR generator are assigned to a specific base.

b. Tenant personnel and aircraft currently located at each base are added to the training phase data.

c. NAS personnel necessary to support the training phase and tenant personnel and aircraft are calculated for each base.

These base specific data are then entered as input to the Facilities Requirements and Total Systems Cost Submodels.

OVERVIEW

C.2 This submodel is an extremely valuable tool for enhancing the flexibility of the IFRS by allowing the decision maker to experimentally assign a training phase to any of the eight existing pilot training bases or to a completely new, or phantom base. Currently, individual phases are assigned completely to one base. However, with the use of the submodel, either a complete or a partial training phase can be assigned to a~~ny of the~~ nine bases by the operator, by typing the appropriate data into the time sharing terminal. With this flexibility,

the analyst could conceivably assign a training phase to as many as nine different locations. The schedule currently used in assigning phases to bases is presented in Table C.1.

C.3 The following hypothetical variations of the current assignments of phase to a base could be tested:

- Assign all training phases to one base
- Assign parts of one phase to several bases
- Assign all phases to two or three bases
- Assign a part of each phase to each base.

This submodel permits the decision maker to examine the effect of a change in phase to base assignment, e.g., a change on the part of NATRACOM from a multiple to a single base training concept.

C.4 The placement of the Base Loading Submodel within the overall context of the IFRS effort is shown in the Introduction to this volume. A more detailed representation of the submodel appears as Figure C.1, which shows the submodel with its associated inputs and outputs. The data inputs include the phase to base assignment selected by the user, the LSR Generator outputs, the Base Data File, and the Aircraft Data File. The data outputs include the complete specification of base loading data, including personnel, aircraft, fuel, and runway requirements for each base to which a phase assignment has been made.

Base Loading Submodel Inputs

C.5 Each of the four input sources shown in Figure C.1 is discussed in the following paragraphs.

C.6 LSR Generator. The following inputs from the LSR Generator are independent of any particular geographic area: 1/

- Phase Personnel—The number of students (average student load), officers, and enlisted men required by each phase for a specific PTR, MIX, and MODE
- Aircraft—The number and types of operational aircraft required by each phase to support a specific PTR, MIX, and MODE
- Fuel—The amount of each type of fuel required annually to support each phase of pilot training
- Runway Requirements—The number and type of "pure" runways required for each phase of training. 2/

1/ See Appendix B for LSR methodology.

2/ See Appendix H for a definition of "pure" runway requirements.

TABLE C.1

CURRENT PHASE TO BASE ASSIGNMENT SCHEDULE*

Phase		NAS	Amount
1	Primary	Saufley	1.0
2	AOC School	Pensacola	1.0
3	Flight Systems	Pensacola	1.0
4	Basic Jet A	Meridian	1.0
5	Basic Jet B	Meridian	1.0
6	Basic Jet CO	Pensacola	1.0
7	Adv Jet	Kingsville	1.0
8	Adv Jet	Chase	1.0
9	Basic Prop	Whiting	1.0
10	Basic Prop CO	Saufley	1.0
11	Adv Prop	Corpus Christi	1.0
12	Pre-Helo	Pensacola	1.0
13	Helo Primary	Ellyson	1.0
14	Helo Advanced	Ellyson	1.0

* 1 January 1970.

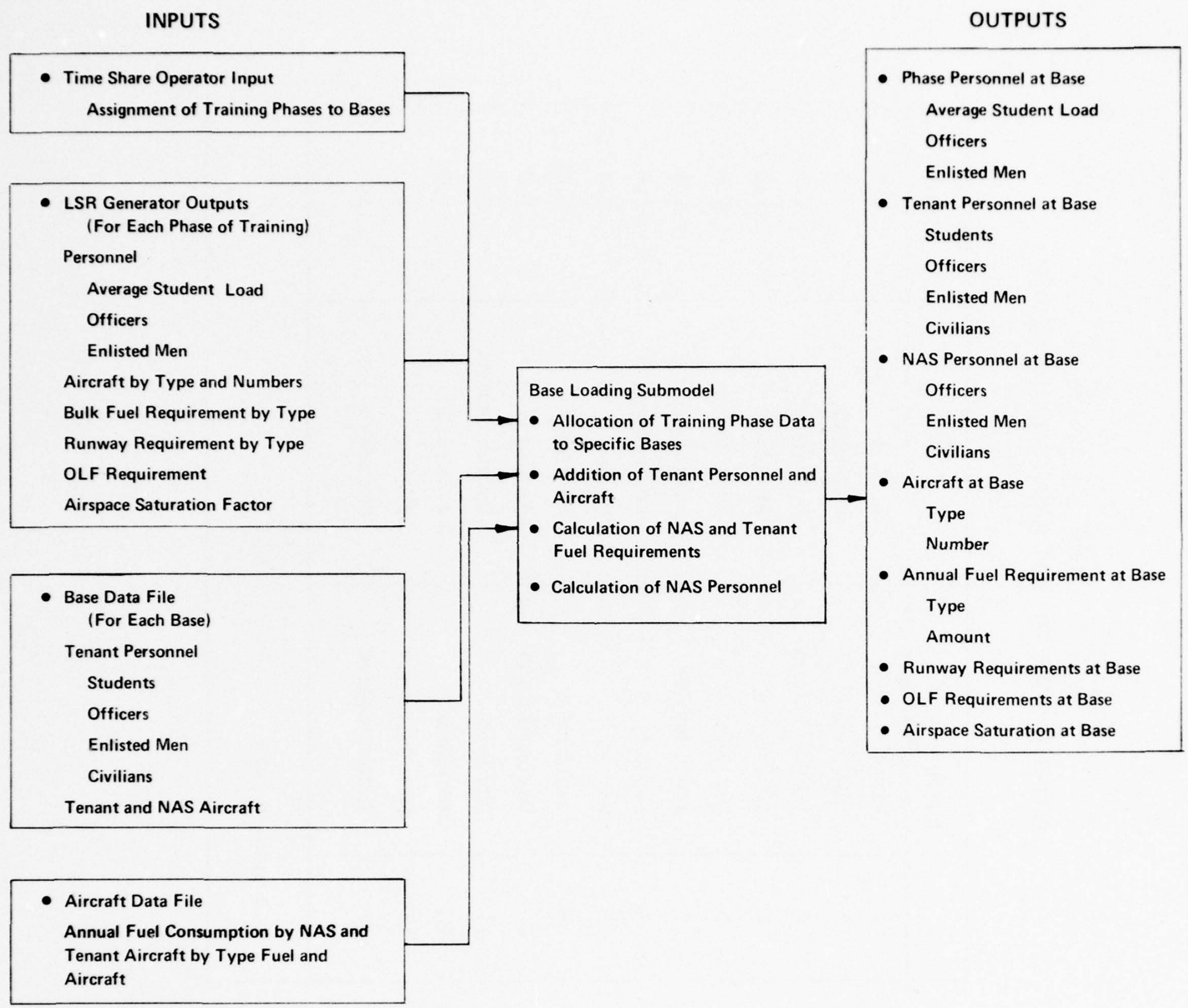


FIGURE C.1. BASE LOADING SUBMODEL INPUTS, OUTPUTS, AND COMPONENT PARTS

- OLF Requirements—The number of outlying landing fields required for each phase of training

- Airspace Factor—The fraction of the total available airspace utilized by each phase of training.

As previously indicated, these inputs are all phase specific, i.e., are not associated with any specific geographic location.

C.7 Base Data File. The following data are contained in the Base Data File:

- Tenant Personnel—The number of tenant students, officers, enlisted men, and civilians at each of the eight existing bases

- Tenant and NAS Aircraft—The number of aircraft not used for pilot training stationed at each base.

These data are base specific and independent of the pilot training program and are used to calculate NAS personnel and fuel requirements at each base. In general, this information should not vary as a function of changes in the pilot training program; it is thus stored in the Base Data File. The tenant personnel data currently in the model are displayed in Annex 1 to this appendix.[3]

C.8 Aircraft Data File. The following data from the Aircraft Data File serve as inputs to the Base Loading Submodel:

- Annual Fuel—The amount of fuel used annually per aircraft by tenant and NAS aircraft, by type of fuel and aircraft.

These data are used to calculate total fuel used by tenant and NAS aircraft at each base. The data in the Aircraft Data File appear in Table E.2 (Appendix E).

C.9 Phase to Base Assignments. These inputs are typed into the on-line terminal by the operator. The current Phase Assignment Schedule is displayed in Table C.1 and is typed into the terminal as shown in Table C.2. The phase number, the first four characters of the base name, and the fraction of the phase assigned to that base are entered until each phase is completely assigned.

C.10 The decisions made by the IFRS program operator in assigning phases to bases is one of the most critical decision points in the IFRS program. Care must be taken to select at least a reasonable combination of phases to bases, or else large facility deficiencies and/or excesses will appear, resulting in either large quantities of unused facilities or large investment costs necessary to offset facility deficits. When selecting phase to base assignments, the operator should be familiar with the approximate sizes of the present operating bases, to be able to make realistic phase assignments.

---

[3] The aggregate of these data appears in Table E.1 of Appendix E.

TABLE C.2

DECISION MAKER INPUT OF PHASE
TO BASE ASSIGNMENT SCHEDULE

```
PHASE ALLOCATION:  ASSIGN EACH PHASE AS--
II,AAAA,.XX
WHERE: II = PHASE (2 DIGITS); AAAA = BASE CODE;
      .XX = PERCENT AT BASE (1.0 = 100%)
BASE CODES: CHAS CORP ELLY
            KING MERI PENS
            SAUF WHIT PHAN
II = 0 TO TERMINATE:?01,SAUF,1.

NEXT?02,PENR,1.

INCORRECT BASE CODE--TRY AGAIN?02,PENS,1.

NEXT?03,PENS,1.

NEXT?04,MERI,1.

NEXT?05,MERI,1.

NEXT?06,PENS,1.

NEXT?07,KING,1.

NEXT?08,CHAS,1.

NEXT?09,WHIT,1.

NEXT?10,SAUF,1.

NEXT?11,CORP,1.

NEXT?12,PENS,1.

NEXT?13,ELLY,1.

NEXT?14,ELLY,1.

NEXT?00
```

C.11 The phantom base is included so that the effect on facility investment costs of building a new base can be determined, if such data are desired. Of course, the phantom base has no tenants and no assets, so the assignment of a phase or phases to this base will require the construction of completely new facilities.

Base Loading Submodel Operation

C.12 The data from the LSR Generator are phase specific, i.e., all calculations of personnel, aircraft, runways, etc., are calculated by phase without reference to a location. The Base Loading Submodel converts these data to base specific data by assigning phases or portions of phases to specific locations, adding in tenant data, and then calculating the NAS personnel required for support of the phase and tenant personnel and aircraft at each location.

C.13 When a phase is assigned to a base, all the LSR generator data shown in Figure C.1, i.e., all personnel, aircraft, fuel, runway requirements, etc., are allocated to that base. If only a portion of a phase is allocated to a base, then the fraction of the phase to be allocated is multiplied by each of the LSR outputs and this fractional phase is assigned to the base. If .5 of a phase is to be assigned to a base, then only .5 times the total phase students, total aircraft, airspace saturation factor, etc. is assigned to the base.

C.14 The number of type t aircraft from phase i assigned to base j is calculated as follows:

$$AC_{ij}^{t} = X_{ij}\, AC_{i}^{t} \qquad \text{(C.1)}$$

where AC_{ij}^{t} = number of type t aircraft from phase i assigned to base j

X_{ij} = percent of phase i assigned to base j (terminal input)

AC_{i}^{t} = number of type t aircraft required by phase i (from LSR Generator).

The total type t aircraft assigned to base j, AC_{j}^{t}, is

$$AC_{j}^{t} = \sum_{i=1}^{n} AC_{ij}^{t} \qquad \text{(C.2)}$$

where n = number of phases.

C.15 Calculation of NAS Personnel. After the assignment of phases to bases, the Base Loading Submodel automatically calculates the total number of NAS personnel needed to support all phase and tenant operations at each base. NAS personnel are those engaged in support activities at the base, including base administration and maintenance (Public Works) personnel.

C.16 The number of NAS personnel required is estimated by an equation derived by regression analysis. 4/ The personnel calculated are average

---

4/ See Appendix K for a discussion of the regression analyses used in the IFRS.

on-board. It seemed reasonable that the number of NAS personnel required at a base would be dependent upon the number of personnel being supported (i.e., phase plus tenant personnel) at that base. The use of linear regression techniques resulted in the following linear equations for estimating NAS personnel. 5/

NAS Officers

$$NOF_i = 19.23 + .1765\ (TO_i) \tag{C.3}$$

where NOF_i = number of NAS officers at base i

TO_i = total number of phase plus tenant officers at base i

NAS Enlisted Men

$$NEM_i = 407.93 + .0939\ (TP_i) \tag{C.4}$$

where NEM_i = number of NAS enlisted men at base i

TP_i = total number of phase plus tenant personnel at base i

Total NAS Personnel

$$NBP_i = 518.354 + 1.259\ (TP_i) \tag{C.5}$$

where NBP_i = total number of NAS personnel at base i

TP_i = total number of phase plus tenant personnel at base i

NAS Civilian Personnel

$$NCV_i = NBP_i - (NOF_i + NEM_i) \tag{C.6}$$

where NCV_i = number of NAS civilian personnel at base i.

The personnel calculated by means of these equations are the NAS personnel required to maintain and operate the NAS in support of the pilot training phases assigned to and tenants located at that NAS.

5/ Each of the equations has a .95 or higher correlation coefficient. The coefficients are significant with 90 percent confidence per the t test.

C.17 Calculation of Tenant and NAS Aircraft Fuel Requirements. Tenant and NAS fuel requirements are calculated in the following manner:

$$TFR_{if} = \sum_{t=1}^{6} (AC_{ift})\ (FC_{ft}) \qquad (C.7)$$

where TFR_{if} = annual tenant fuel consumption of type f fuel at base i

AC_{ift} = number of aircraft of type t using fuel type f at base i

FC_{ft} = annual fuel consumption per aircraft of type f fuel and type t aircraft.

The summation is taken over all tenant and NAS aircraft types (six types maximum). The fuel requirements derived in this part of the Base Loading Submodel are combined with phase fuel requirements assigned to a base to obtain total fuel requirements for each base. A listing of the variables contained in the Base Loading Submodel is presented in Annex 2 of this appendix.

Submodel Outputs

C.18 The data outputs of the Base Loading Submodel listed in Figure C.1 are calculated separately for each base to which a partial or complete phase is assigned. If a base has no phase assigned to it, the base is deleted from the submodel printout. Two types of on-line terminal printouts are produced. An example of the first type of display is given in Table C.3 for a PTR of 2510 and the phase assignment shown in Table C.2. This display is a summary of the pertinent base loading data for each base, including student load; total phase personnel; total NAS personnel; phase, NAS, and tenant personnel subdivided into officers, enlisted, civilians, and total; number and type of aircraft; and amount and type of fuel required by the base. Tenant and NAS aircraft and fuel requirements are not included. A summary of the airspace factors and OLFs required for each phase at each base is given; Meridian and Corpus Christi are used as examples.

C.19 If specified by the time share operator, a detailed base loading printout similar to that shown in Table C.4 (for NAS Meridian) can be obtained. The printout gives a detailed accounting of base personnel, all aircraft, and total annual fuel requirements, including that for NAS and tenant aircraft. The runway requirements at each base are also available as an output of the Base Loading Submodel. The complex calculations involved in the generation of the runway requirement are discussed in Appendix H.

TABLE C.3

BASE LOADING SUBMODEL OUTPUT:
SUMMARY DATA

a. Personnel, Aircraft, and Fuel Summary

BASE LOADING SUMMARY

*PERSONNEL								*AIRCRAFT		*FUEL	
	STD.	------------BASE TOTALS ------------								MILLION GAL.	
NAS	LOAD	PHASE	NAS	OFF 1/	ENL 1/	CIV 1/	TOTAL 1/	TYPE	NO.	TYPE	AMOUNT
CHAS	201.	1706.	960.	271.	1858.	335.	2666.	TA4J	156.	JP-4	47.76
CORP	325.	2180.	2565.	602.	3639.	5900.	10466.	TS2A	164.	A115	12.45
ELLY	143.	874.	745.	160.	1101.	214.	1619.	TH57	21.	AGAS	2.61
								H-34	54.		
KING	201.	1826.	991.	276.	1986.	354.	2817.	TF9J	174.	JP-4	60.12
MERI	432.	2149.	1079.	388.	2029.	393.	3243.	T-2A	99.	JP-4	46.15
								T2BC	103.		
PENS	813.	1546.	2914.	792.	2836.	7782.	12163.	T2BC	59.	JP-4	11.52
								T28C	18.	AGAS	0.71
SAUF	526.	1400.	881.	318.	1160.	278.	2282.	T34B	131.	AGAS	2.43
								T28C	36.		
WHIT	658.	2339.	1135.	414.	2005.	441.	3518.	T28C	263.	AGAS	10.10

DO YOU WISH TO RE-ALLOCATE PHASES TO BASES (Y,N)?N

1/ Includes tenant personnel.

b. Airspace and Outlying Field Summary

```
NAS--MERI
  TYPE A/C     AIRSPACE    OLF'S
                FACTOR   REQUIRED
    T-2A         1.32       0.15
    T2BC         1.36       0.12
NOTE: AIRSPACE IS OVER-SATURATED
DO YOU WISH TO CONSTRAIN LSR OUTPUT (Y,N)?N

NAS--CORP
  TYPE A/C     AIRSPACE    OLF'S
                FACTOR   REQUIRED
    TS2A         0.31       0.17
```

TABLE C.4

BASE LOADING SUBMODEL OUTPUT:
DETAILED DATA, NAS MERIDIAN

NAS--MERI

PERSONNEL	STD.LOAD	OFFICERS	ENLISTED	CIVILIAN	TOTAL
BASIC JET-A	242.	167.	598.		1007.
BASIC JET-B	190.	140.	812.		1142.
ALL PHASES	432.	308.	1409.		2149.
TENANTS		6.	9.	0.	15.
NAS PERS.		75.	611.	393.	1079.
TOTAL BASE		388.	2029.	393.	3243.

AIRCRAFT DATA

TYPE	NO.
T-2A	99.
T2BC	103.
VT	2.
H	2.

FUEL DATA

TYPE	GALLONS
JP-4	0.461E+08

APPENDIX C

ANNEX 1

PILOT TRAINING TENANT DATA 1/

C1.1 The tenant personnel for each base was calculated by deleting from the total personnel figures the following items:

1. Naval Air Station personnel
2. Squadron personnel
3. Public Works Center personnel 2/
4. Personnel assigned to Naval ships
5. Students assigned to the base.

The calculations are broken down into Officers, Enlisted men, and civilians. Of the eight (8) bases used, only four (4) of them had any tenant personnel requiring this method of calculation.

SUMMARY OF TENANT PERSONNEL

Base	Officers	Enlisted Men	Civilian	Total
Chase	0	0	0	0
Corpus Christi	239	890	4,592	5,721
Ellyson	0	0	0	0
Kingsville	0	0	0	0
Meridian	0	9	0	9
Pensacola	529	954	6,220	7,703
Saufley	0	0	0	0
Whiting	2	26	16	44

1/ Information obtained from Naval Air Training Command, Facilities, Personnel, and Aircraft Summary, January 1969 (Unofficial publication.)

2/ Assumed to be part of the NAS personnel.

TENANT PERSONNEL FOR IFRS*

Units	Officers	Enlisted	Civilian	Total
Pensacola:				
NAVFAC	2	0	22	24
VT - 10	49	138	15	202
NAVAVSCOLSCOM	132	107	52	291
CNATRA Staff	51	54	75	180
CNABATRA Staff	51	60	51	162
MAD	5	36	0	41
NAVAVMEDCEN	10	29	79	118
NAMI	53	88	142	283
NAVHOSP	120	192	138	450
NAVINVOFF	1	0	12	13
NAO	2	0	13	15
OINC CONSTRUCTION	4	0	37	41
FAA	0	0	35	35
NATTU & MARDET	17	125	54	196
NAVAIRSYSCOMREP	3	8	106	117
NAVTRADEVCENTEGOFC	0	0	29	29
NAVEXCH	3	2	383	388
COMSTY	3	16	79	98
NAVMUS	1	6	3	10
NPPSO	0	0	30	30
FLWEAFAC	3	25	4	32
NARF	16	40	4,852	4,908
FLTINTELLOF	1	0	0	1
NAMTRADET	0	8	0	8
NAVRESTRACEN	1	10	0	11
USNH PENS. VETS	1	10	0	11
NATIONAL CEMETERY	0	0	9	9
Total	529	954	6,220	7,703
Whiting:				
Weather Service	1	12	0	13
Commissary	1	14	16	31
Total	2	26	16	44

*Naval Air Training Command, Facilities, Personnel, and Aircraft Summary, January 1969. (Unofficial publication.)

TENANT PERSONNEL FOR IFRS (Cont)

Unit	Officers	Enlisted	Civilian	Total
Meridan:				
NAMTRADET #1004	0	9	0	9
Total	0	9	0	9
Corpus Christi:				
NAVANTRACOM	46	48	24	118
VT - 29	65	216	0	281
MAD	4	12	0	16
Naval Hospital	58	167	124	349
NRTC	1	9	0	10
CG Res Trng Ctr	0	1	0	1
CG Air Station	12	41	0	53
ARADMAC	53	396	4,444	4,893
Total	239	890	4,592	5,721

C1.2 The tenant information currently stored in the Base Data File is based on the unofficial publication, Facilities, Personnel, and Aircraft Summary. The study team concluded that this unofficial publication contained more current data than other available documents since it was recently updated, the mission of these bases has not changed recently, and future year projections of other documents are generally extensions of current year levels. However, in Phase III, the tenant data contained in the LSR submissions of the bases will be incorporated into the Base Data File. (No programming changes are required.)

APPENDIX C

ANNEX 2

SUMMARY OF THE VARIABLES CONTAINED IN THE BASE LOADING SUBMODEL

Symbol	Description	Source
AC_i^t	Number of aircraft of type t required in phase i	LSR Generator
BF_i^f	Amount of fuel of type f in phase i	LSR Generator
IF_i^{fl}	Number of instructors (flight) in phase i	LSR Generator
EM_i	Number of enlisted support personnel in phase i	LSR Generator
AM_i	Number of administration-supervisory officers in phase i	LSR Generator
IUT_i^{af}	Average number of flight instructors undergoing training in the i^{th} training phase	LSR Generator
SL_i	Average student load of phase i	LSR Generator
EM_j^t	Number of tenant enlisted men assigned to base j	Base Data File
OF_j^t	Number of tenant officers assigned to base j	Base Data File
CV_j^t	Number of tenant civilians assigned to base j	Base Data File

Symbol	Description	Source
EM_j^s	Number of enlisted men assigned to the NAS at base j	Calculated
OF_j^s	Number of officers assigned to the NAS at base j	Calculated
CV_j^s	Number of civilians assigned to the NAS at base j	Calculated
AS_j^t	Number of aircraft of type t assigned to the NAS at base j	Aircraft Data File
AT_j^t	Number of tenant and NAS aircraft of type t assigned to base j	Aircraft Data File
TO_j^s	Total officers in squadrons and tenant	Calculated
TE_j^s	Total enlisted men in squadrons and tenants at base j	Calculated
TP_j^s	Total personnel in squadrons and tenants at base j	Calculated
TBP_j	Total base personnel of base j	Calculated
$X_{i,j}$	Percent of phase i assigned to base j	Operator Input

APPENDIX D

FACILITIES REQUIREMENTS SUBMODEL

INTRODUCTION

D.1 The purpose of the Facilities Requirements Submodel is to calculate the quantity of specified permanent facilities required to support CNATRA's pilot training program. Permanent facilities, as defined in this study, are those designated by the Department of the Navy, Bureau of Yards and Docks, as "Class II-Buildings and Improvements."1/ The broad categories included within Class II facilities are pavements, (e.g., runways), all structures and buildings (including maintenance, supply, medical, housing, and administrative facilities), utilities, and ground improvements. Excluded from Class II facilities are real estate and such movable equipment as aircraft, electronic equipment, and vehicles. Thus, the Facilities Requirements Submodel computes only those major facilities which are permanent fixtures at a naval air station (NAS).

D.2 The type and quantity of facilities required at a naval air station are dependent on the mission being pursued at the installation and the number of personnel and aircraft required in support of that mission. The Facilities Requirements Submodel in the context of the overall IFRS effort is shown in Figure A.1 in the Introduction to this volume. As shown in that figure, the inputs into the submodel come from the Base Loading Submodel, Base Data File, and the Aircraft Data File. The Base Loading Submodel assigns to each base the number of Phase, NAS, and tenant personnel; the number of aircraft; and the amount of aircraft fuel used at each base. The Base Data File contains base specific data for each of the eight bases under study and a new or phantom base. The Aircraft Data File contains data on up to 21 aircraft types. The Facilities Requirements Submodel

1/ A comprehensive list of facility types within this class is given in Department of the Navy, Bureau of Yards and Docks, Category Codes for Classifying Real Property of the Navy, NAVDOCKS P-72, Washington, D.C., April 1966.

utilizes these three data sources to generate the fixed facilities required at each naval air station to support all operations at the base. The requirements are generated through the use of mathematical expressions for each facility which convert the input data into the required amount of each facility. Note that the facility requirements are base specific, i.e., requirements are calculated separately for each base whereas those developed in the Phase I study were phase specific.

IFRS FACILITY SELECTION

D.3 The total number of category codes of Class II property listed in NAVDOCKS P-72 is in excess of 800. However, no single naval air station has this number of facility codes. A comprehensive list of facilities for the eight NAS's presently training naval aviators indicates a total of approximately 400 facility types for all eight bases, with any single base listing approximately 200 different facility codes. To preserve the usefulness of IFRS as a management planning tool, it was not possible to include all facilities listed at all bases. Therefore, this comprehensive list was narrowed to approximately 60 facility types which can be considered major cost facilities for each of the eight bases under study. These are facilities such as runways, fuel storage tanks, maintenance hangars, family housing, utilities, etc., which are common to the eight naval air stations and which together comprise up to 80 percent of the cost of building a naval air station. It is from these 60 facility types that the facilities included within the Facilities Requirements Submodel were selected.

D.4 The facilities included within the final Facilities Requirements Submodel are listed in Table D.1, together with the approximate percent of total base replacement cost which they represent for each of the eight bases in the present study. In all, there are 24 separate facility expressions encompassing approximately 50 separate category codes. The number of category codes is considerably greater than the number of facilities because facilities such as family housing are listed under a number of codes depending on the type. Also, facilities such as "Aircraft Operations Building" and "Control Tower," while two separate category codes, are generally built as one unit and were therefore considered to be one facility throughout the IFRS Model.

D.5 The percent-of-cost shown in Table D.1 is the percent of cost for each category code including the main base and any activities or noncontiguous areas 2/ listed under its command. Activities and noncontiguous area facility costs were included within the categories of Table D.1 because, in general, they are a functioning part of the main base and the facilities are utilized by personnel (either phase, NAS, or tenant) stationed at that base. Outlying landing fields and the Auxiliary Landing Field of Orange Grove are not included in the table.

2/ See Department of the Navy, Detailed Inventory of Naval Shore Facilities, NAVFAC P-164, Vol. I, 30 June 1968, pp. XII-XIII, for definitions of activities and noncontiguous areas.

TABLE D.1

IFRS FACILITY REQUIREMENTS LIST, INCLUDING PERCENT OF TOTAL BASE REPLACEMENT COST

IFRS Category Code	Navy Category Code	Facility	Percent of Total NAS Replacement Cost *							
			Chase	Corpus Christi	Ellyson	Kingsville	Meridian	Pensacola	Saufley	Whiting
—	111-10, 111-11, 111-12 (111-80)	Runways **	12.0	05.2	14.9	10.2	20.4	02.5	09.0	12.6
—	112-10, 112-11, 112-12 (112-80)	Taxiways	05.1	03.1	00.3	03.9	02.3	01.0	04.0	03.2
113-20	113-20, 113-21, 113-22 (113-81)	Aircraft Parking Apron **	04.5	02.1	16.7	03.5	06.1	02.6	02.9	03.9
—	124-30	Aircraft Ready Fuel Storage Tank **	00.9	01.6	00.2	03.3	00.4	00.4	00.2	00.7
125-40	125-40	Distribution Pipeline (Fuel)	—	01.1	02.0	01.7	00.4	01.0	—	00.3
—	136-30	Runway Lighting	01.3	00.4	—	00.3	00.6	00.1	03.1	00.8
141-40	141-40, 141-70	Aircraft Operations Building With Control Tower	01.6	00.9	—	01.5	01.4	00.3	—	—
171-10	171-10	Academic Building **	02.1	00.6	01.2	00.5	—	00.2	02.6	00.8
211-10	211-10	Aircraft Maintenance Hangar **	07.3	22.7	07.4	12.7	05.1	15.3	07.9	09.8
219-10	219-10	Public Working Maintenance Shop	01.8	00.6	00.0	00.8	00.5	00.4	01.1	00.3
442-10	442-10, -20, -30, -60, -65, -90	General Warehouse	02.1	05.1	01.8	04.0	01.9	04.9	01.4	01.1
550-10	550-10, 550-20	Dispensary With and Without Beds	01.2	00.5	01.5	02.0	01.7	00.3	01.3	00.6
610-10	610-10	Administrative Office	01.6	01.3	02.6	01.7	01.1	03.3	03.9	01.0
711-10	711-10 through -62	Family Housing (Officer and Eligible EM) **	09.9	05.5	—	04.5	11.5	01.5	—	10.4
None	None	Family Housing (Ineligible EM)	—	—	—	—	—	—	—	—
722-10	722-10, 722-20	EM Barracks With/Without Mess **	04.6	02.4	06.6	06.3	04.5	03.2	09.8	04.2
723-10	723-10	Mess Hall **	01.4	00.5	03.4	01.3	01.1	00.2	01.6	01.1
724-15	724-10, 724-15	BOQ's With/Without Mess **	03.6	01.2	05.4	02.6	06.0	01.5	01.8	03.7
740-14	740-14	Exchange	—	00.8	02.8	01.7	01.5	00.9	00.0	01.3
740-63	740-63	EMs Service Club	00.7	00.4	—	00.4	01.0	00.1	02.0	00.8
812-30	812-30	Distribution Line (Electrical)	02.6	04.6	03.1	04.3	01.7	08.0	02.9	03.0
842-10	842-10	Water Distribution Line (Potable)	02.0	01.9	01.0	03.5	01.1	04.1	00.6	01.5
851-10	851-10, 851-11, 851-12 (851-80)	Roads	02.4	02.4	01.0	02.6	03.0	01.9	00.7	01.8
852-10	852-10, 852-11, 852-12 (852-80)	Parking Areas	00.7	00.8	00.6	01.1	00.6	00.5	00.7	00.2
Total Percent of Total Replacement Cost			69.4	65.7	72.5	74.4	73.9	54.2	57.5	63.1

* Derived from data in, Detailed Inventory of Naval Shore Facilities, NAVFAC P-164, 30 June 1968, including the main base, and the activities and non-contiguous areas for each base but excluding outlying and auxiliary landing fields.

** Indicates facilities included in the Integrated Facilities Requirements Study, Phase I, ORI TR 520, 5 December 1968.

D.6 The actual selection of the facilities shown in Table D.1 proceeded in the following manner. First a complete list of all facility category codes listed at any of eight bases under study was made using both NAVFAC P-164 3/ (Real Property Inventory of each base) and the Individual "Basic Facility Requirements Listing." 4/ As previously indicated, this list included about 400 separate category codes. The estimated replacement cost 5/ for each of these facilities, as listed in NAVFAC P-164 was then recorded for each facility category code and these costs were converted to percent of total base replacement costs (= facility replacement cost ÷ total base replacement cost). The complete lists of facilities and the facility replacement and percentage of total replacement costs were carefully reviewed and a preliminary listing of high cost facilities was made. The percentage of total replacement costs appeared to be a more consistent indicator of relative cost importance than the facility replacement cost and thus was used to identify the facilities included within the initial list.

D.7 The preliminary listing of facilities to be considered as well as the comprehensive facility listings were then reviewed with NAVFAC officials 6/ for agreement on both their cost importance and their importance and relevance to pilot training programs. It was agreed that the preliminary list included all facilities considered most critical to the present program and that the IFRS Facilities Requirements Submodel should include as many of these facilities as possible.

D.8 The preliminary list of facilities included those appearing in Table D.1 plus the following:

- 116-90, 91 Miscellaneous Pavements
- 171-20 Applied Instruction Building
- 811-60 Standby Generator Plant
- 832-10 Sanitary Sewer
- 841-10 Water Treatment Facilities
- 860-10 Railroad Trackage
- 871-10 Storm Sewer
- 871-20 Drainage Ditch
- 872-10 Security Fencing and Walls.

These facilities were not incorporated within the final IFRS model because it was impossible to derive a general expression which would accurately compute requirements for them within the context of the Phase II study. In addition, they were not considered to be a critically limiting factor in pilot training programs.

3/ Ibid.

4/ "Basic Facility Requirements Listing," OPNAV Form 11000-1, 1965-68 versions.

5/ The "Replacement Cost Factor" column of NAVFAC P-164 was used as the estimated replacement cost. This column gives a present (1968) money value for each facility derived by inflating the original cost of the facility by the Marshall Stevens Index of 2.1 to 2.5 percent per year.

6/ Meeting on 12 June 1969 with LCDR D.L. McCorvey and Mr. Dennis Whang of NAVFAC.

D.9 In addition to the facilities listed in Table D.1, the following additional major facility types are required for certain specific phases of training:

- Aircraft Carrier
- Air-to-Air Gunnery Range
- Air-to-Ground Target Areas
- Outlying Landing Fields.

Aircraft carrier and Air-to-Air Gunnery Ranges, when available, should be able to handle any reasonable pilot training rate. These two facilities are not included in the model, but the availability of each must be considered by the decision maker when assigning phases to bases. Target Areas and Outlying Landing Field requirements are calculated in the LSR Generator, 7/ since these facilities are a function of a specific phase of training.

OVERVIEW OF FACILITIES REQUIREMENTS SUBMODEL

D.10 Figure D.1 presents a detailed overview of the operation of the Facilities Requirements Submodel. As indicated previously, the Facilities Requirements Submodel is actually a set of 27 expressions, each of which uses input data from the Base Loading Submodel, the Base Data File, and/or the Aircraft Data File to compute the requirement for a specific facility. Runway requirements are actually computed directly in the LSR Generator and assigned to a base by the Base Loading Submodel. The special facilities shown are also computed in the LSR Generator and requirements for them are assigned to a base in the Base Loading Submodel.

Facilities Requirements Submodel

D.11 Figure D.1 diagrams the 27 expressions of the Facilities Requirements Submodel by category code and name, indicating the model inputs and the output consisting of units of each facility required. The three major input sources are:

- Base Loading Submodel, 8/ which assigns training phases to bases and calculates NAS and other personnel required at the base
- Base Data File, 9/ which contains such base specific information as number of tenant personnel and parking apron depth.

7/ The LSR Generator is discussed in Appendix B.

8/ The Base Loading Submodel is discussed in Appendix C.

9/ The information contained in the Base Data File is discussed in Appendix E.

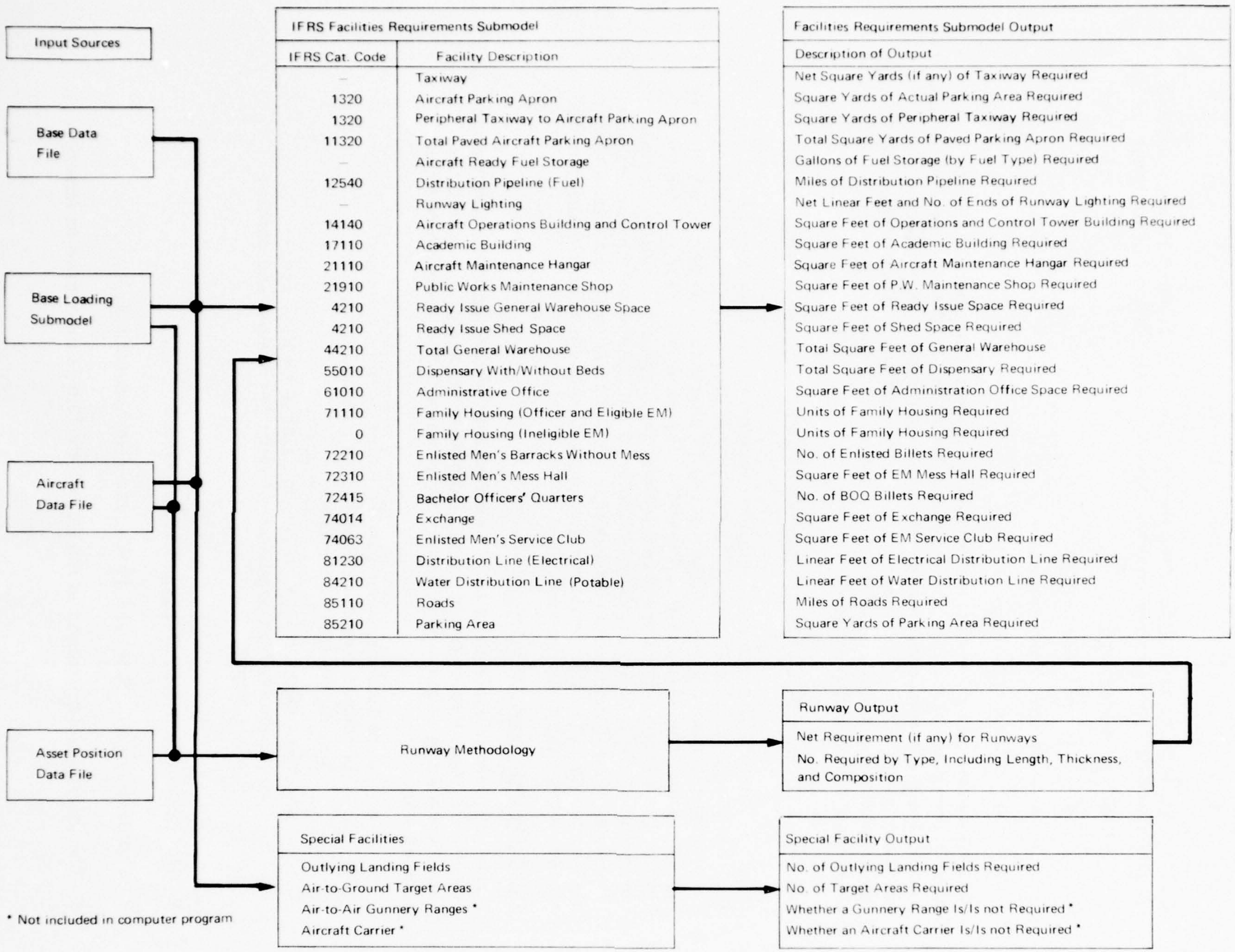


FIGURE D.1. OVERVIEW OF BASE FACILITIES REQUIREMENTS CALCULATIONS

- Aircraft Data File,[10] which contains data on each type of aircraft, including such items as aircraft parking measurements and aircraft per maintenance hangar module.

D.12 The actual calculation of the required amount of each facility is carried out in the submodel using mathematical expressions derived from a variety of sources. The major sources of planning factors utilized in the models were IFRS Phase I, and NAVFAC P-80,[11] but other sources were carefully checked and incorporated whenever appropriate in the final expressions. The final methodology for each facility includes the most recent and accurate planning data available to the study. The detailed derivation including category code, facility name, definition of the facility, details of the requirement calculation, and the sources of the calculation and independent variables for each facility are presented in the Annex to this appendix.

D.13 One of the major problems encountered during the facility modeling was the definition of exactly what facilities were and were not included within a specific facility model. For example, NAVFAC P-80 specifies that the expression given in its planning factors for Covered Storage, Ready Issue, covers all ready issue storage at an NAS, presumably including most category codes of the 442 series. However, many naval air stations, when computing their individual BFRLs, did not include all of the appropriate category codes within this gross calculation and computed separate requirements for facilities which should have been included in the original calculation. This practice is just one example of the problems encountered with many of the facilities. In general, the IFRS study resolved this problem by carefully defining exactly which facilities were included in the model and then making all relevant data consistent with this definition. Definitions of facility calculations are given as required in the individual model derivations in the Annex, and all data used in this report are as consistent as possible with these definitions. Thus, the data in the Asset Position Data File, and other sources of data used in the program, are based on these definitions.

D.14 With the exception of Taxiways and Runway Lighting,[12] the Facilities Requirements Submodel calculates the gross requirements for each facility at each naval air station. This represents the total amount of each facility required to support the number of squadron, NAS, and tenant personnel and aircraft with the given training phases at that base. Thus, to obtain the net requirement for facilities, existing assets must be subtracted from the gross requirement; this operation is performed in the Excess/Deficiency Submodel.[13]

10/ See Appendix E for the information presently in the Aircraft Data File.

11/ Dated January 1968.

12/ As discussed in the Excess/Deficiency Submodel (Appendix G), Taxiways, and Runway Lighting are calculated as a net requirement because of their dependence on runway requirements.

13/ See Appendix G for the Excess/Deficiency Submodel discussion.

D.15 It is important to note that the Facilities Requirements Submodel is base-specific, i.e., the requirements are unique to a base, resulting from the fact that base specific data (from the Base Data File) are incorporated into the calculation of the requirements. Therefore, in general, the submodel does not necessarily duplicate gross facility requirements, assuming that identical phases are assigned to two different bases.

Runway Methodology

D.16 The Runway Methodology with its associated inputs and outputs is also indicated in Figure D.1. Because of its complexity, the runway requirements calculation is discussed in a separate section (Appendix H); however, since the requirements are part of the fixed assets of a base, they are included in Figure D.1. Briefly, the runway requirement calculation proceeds in the following manner. The LSR Generator computes "pure" runway requirements per aircraft utilizing such inputs as syllabus flying hours, overhead flying hours, aircraft launch cycle time, and average length of a flying day. These requirements are called "pure" because they are not corrected for wind rose data, temperature, and altitude. These runway requirements are then assigned to a base by the Base Loading Submodel and compared with existing runway assets at that base. The runway calculations take wind rose data into consideration and compute any net deficiencies. Any deficient runways are assumed to be built as either main or crosswind with specific length, thickness, and material composition as a function of the aircraft using the runway.

Special Facilities

D.17 The four facilities listed at the bottom of Figure D.1 are facilities vital to pilot training programs but not, in the strictest sense, permanent facilities at a base. The inclusion of these facilities was felt to be important because of their criticality to specific phases of pilot training programs. Because these facilities are tied to phases of training, or more specifically, to particular courses of instruction within phases, the requirement for two of them is calculated in the LSR Generator and then assigned to bases in the Base Loading Submodel.

D.18 The requirements for Air-to-Ground Target Areas and for outlying fields are calculated in specific amounts in the LSR Generator. For a detailed explanation of these calculations, see Appendix B. The requirements for Aircraft Carriers and Air-to-Air Target Areas are assumed to have been met if they are available at all. For example, if an aircraft carrier is needed for a specific phase of training, it is assumed that one carrier is sufficient to meet all requirements. Similarly, Air-to-Air Target Areas are assumed to be available in adequate quantities if they are available at all. The decision maker must verify the requirement for and availability of these last two facilities.

MODEL ASSUMPTIONS

D.19 Two major implicit assumptions are necessary for the use of the Facilities Requirements Submodel. The first is the assumption of "pipeline flow" made

earlier in this study. For the present submodel this implies that requirements are computed on an average base loading basis rather than a "peak" utilization period.

D.20 The second assumption is that a general mathematical model with the proper data can accurately predict facility requirements. This assumption is made in many planning documents, including NAVFAC P-80, the source of many of the planning factors used here. Only to the extent that this is true will the Facilities Requirements Submodel be accurate without detailed base specific data inputs. This generalization is probably the biggest limitation on the submodel's accuracy. While base specific data are used in some of the models to help correct for the gross effects of this assumption, it was not possible or desirable to use all the base specific data necessary to compute an exact requirement. Some requirements may be so base specific that individual models would be needed for each base to compute an exact requirement. This was not considered either possible within the scope of the study or particularly desirable for IFRS.

D.21 In addition to the two major assumptions made above, specific assumptions are made for some of the IFRS Facility Requirements expressions. These assumptions are noted in the individual derivations given in the Annex to this appendix.

SAMPLE OUTPUTS

D.22 A sample computer output of the IFRS Facilities Requirements Submodel is shown in Figure D.2, and sample outputs for the Runways and Special Facilities in Figure D.3. All of these outputs are based on the exemplary 2,510 PTR.

General Format

D.23 The basic format of the requirement printout shown in Figure D.2 is:

a. IFRS facility category code
b. Brief description of the facility
c. Amount of the facility required
d. Unit of measure of the requirement.

This format is followed for all facilities except (a) Taxiways and Runway Lighting which, as previously indicated, are computed differently; and (b) Ready Fuel Storage, which has a different excess deficiency comparison format. The requirements for these facilities are also indicated in Figure D.2.

D.24 The category code indicated in Figure D.2 is the IFRS category code, which in many cases is only one of several category codes included in that facility group requirement. For a detailed list of which Navy category codes are included in each requirement, see the Annex to this appendix.

CODE	DESCRIPTION	REQUIRED AMOUNT	UNIT
1320	A/C PKNG APN	221667.	SY
1320	PER TAXIWAY	128333.	SY
11320	TOT PKNG APN	350000.	SY
12540	DIST PIPELIN	3.	MI
14140	A/C OP BLDG	16956.	SF
17110	ACADEMC BLDG	5758.	SF
21110	MAINT HANGAR	222732.	SF
21910	PW MAINT SHP	9364.	SF
4210	GEN WAREHOUS	125000.	SF
4210	SHED SPACE	8074.	SF
44210	TOT WARHSE	133074.	SF
55010	DISPENSARY	17037.	SF
61010	ADMIN OFFICE	51447.	SF
71110	FAM HOUSING	1319.	UN
0	INELIG HOUSE	208.	UN
72210	EM BARRACKS	937.	MN
72310	EM MESS HALL	11941.	SF
72415	BOQ	325.	MN
74014	EXCHANGE	13050.	SF
74063	SERVICE CLUB	12685.	SF
81230	ELEC DIST LN	115876.	LF
84210	WATER DIS LN	53463.	LF
85110	ROADS	20.	MI
85210	PARKING AREA	83729.	SY

TAXIWAYS & RUNWAY LIGHTING
NO DEFICIENCY
READY FUEL STORAGE
REQUIRED: (THOUSANDS OF GALS)
JET 1374.7
AVGAS 12.1

FIGURE D.2. SAMPLE PRINTOUT OF FACILITIES REQUIREMENTS SUBMODEL

• RUNWAY REQUIREMENTS BY BASE

```
NAS--MERI
AVAILABLE:
AMOUNT LENGTH THICKNESS
 0.90    8000.       9
 0.90    8000.       9
 0.74    6400.       9
REQUIRED:
AMOUNT LENGTH THICKNESS
 0.82    5000.       1
 0.64    5000.       1
 NO RUNWAY DEFICITS

NAS--CORP
AVAILABLE:
AMOUNT LENGTH THICKNESS
 0.84    8000.       9
 0.84    5000.       2
 0.82    5000.       2
 0.62    5000.       2
 0.64    5000.       2
REQUIRED:
AMOUNT LENGTH THICKNESS
 1.36    8000.       2
UPGRADE: LENGTH: 5000. TO  8000.
THICKNESS:       2 TO       2
COST:     424. (THOUS.)
SUMMARY OF RUNWAY UPGRADE/CONSTRUCTION
NO. LENGTH THICKNESS COST (THOUS.)
 1    8000.      2       424.
 WILL THESE DEFICITS BE MADE UP (Y,N)?Y
```

• AIRSPACE FACTORS & OLF'S REQUIRED

```
NAS--MERI
  TYPE A/C     AIRSPACE   OLF'S
                FACTOR  REQUIRED
     T-2A        1.00      0.37
     T2BC        1.00      0.29

NAS--CORP
  TYPE A/C     AIRSPACE   OLF'S
                FACTOR  REQUIRED
     TS2A        0.25      0.43
```

FIGURE D.3. RUNWAY AND SPECIAL FACILITIES REQUIREMENTS

D.25 In addition to the basic IFRS category codes, two facilities are sub-divided into two subcategories to enhance the usefulness of the printout in the management decision process. Category 113-20 Total Parking Apron (11320 TOT PKNG APN) is divided into 1320 actual parking area occupied by aircraft (1320 A/C PKNG APN) and 1320 the area of the peripheral taxiway around the parking area (1320 PER TAXIWAY). Category 442-10, Total Warehouse Space (44210 TOT WAREHSE) is divided in 4210 general warehouse space (4210 GEN WAREHOUS) and 4210 shed space (4210 SHED SPACE).

D.26 The "Description" column of Figure D.2 includes a brief description of each of the facilities as permitted by time share terminal printing width constraints. The "Amount" column gives the computed requirement for each facility, while the "Unit" column gives the units in which this requirement is expressed. The abbreviations of the units are as follows:

GALS	gallons
LF	linear feet
MI	miles
MN	men
SF	square feet
UN	units (in this case, families).

D.27 Because the requirements for Taxiways and Runway Lighting are computed on a net requirement basis instead of the gross requirements computed for other facilities, they are indicated separately in Figure D.1 and are printed out as either no deficiency or the net requirement for Taxiways in square yards of pavement and the net requirement for Runway Lighting in linear feet.

D.28 Fuel Storage Requirements are also printed out separately because they are computed separately for each fuel type and the net requirement (if any) is computed in number of tanks by size of tanks.

Runway and Special Facilities

D.29 Figure D.3 gives a sample output for the runway requirements and the requirements for the special facilities considered in the study. The runway requirements and the requirements of the special facilities are discussed in detail in Appendix H and are included here to indicate the position of these facilities in the model and the general format of the requirement output. Note that the model states that one runway must be lengthened for NAS Corpus Christi.

14/ See Appendix F for the Assets Position Data File.

APPENDIX D

ANNEX 1

DERIVATION AND DESCRIPTION OF FACILITIES INCLUDED WITHIN THE FACILITIES REQUIREMENTS SUBMODEL

FACILITIES INCLUDED WITHIN THE FACILITIES REQUIREMENTS SUBMODEL

Primary Category Codes[1]	Alternative Category Codes[2]	Facility Description	Page No.
112-10, 112-11, 112-12 (112-80)		Taxiways	D-1-5
113-20, 113-21, 113-22 (113-81)		Aircraft Parking Apron[3]	D-1-8
124-30	411-20	Aircraft Ready Fuel Storage Tank[3]	D-1-11
125-40	125-30	Distribution Pipeline (Underground)	D-1-13
136-30		Runway Lighting	D-1-14
141-40, 141-70		Aircraft Operations Building With Control Tower	D-1-16
171-10		Academic Building[3]	D-1-17
211-10		Maintenance Hangar[3]	D-1-19
219-10		Public Works Maintenance Shop	D-1-23
442-10, 442-20, 442-30, 442-60, 442-65, 442-90		Covered Storage, Ready Issue	D-1-25
550-10, 550-20		Dispensary With and Without Beds	D-1-27
610-10		Administrative Office	D-1-29
711-10 through -62	712-, 713-	Family Housing (Officer and Eligible Enlisted)[3]	D-1-30
		Family Housing (Ineligible Enlisted)	D-1-32
722-10, 722-20	721-10 721-20	Enlisted Men's Barracks Without Mess[3]	D-1-33
723-10	721-10 721-20	Mess Hall[3]	D-1-34
724-15	724-10	BOQs Without Mess[3]	D-1-36
740-14		Exchange	D-1-37
740-63		Enlisted Men's Service Club	D-1-39
812-30		Distribution Line (Electrical)	D-1-40
842-10		Water Distribution Line (Potable)	D-1-41
851-10, 851-11, 851-12 (851-80)		Roads	D-1-42
852-10, 852-11, 852-12 (852-80)		Auto Parking Areas	D-1-43

[1] The Primary Category Codes are those codes listed in NAVDOCKS P-72 which best describe the facilities in the IFRS. Generally, these codes are applied accurately by individual naval air stations to the listing in their RPIs (NAVFAC P-164) and to other data forms used by that NAS. However, occasionally a facility is miscoded, hidden within another facility (listed under that facility's code), listed under an alternative code, or is not coded at all (as in the case of off-base housing). These "hidden" facilities and/or facility codes, although not listed under the Primary Category Codes column, were included within the appropriate code in the Assets Position Data File so that all facilities being used in a similar manner would be grouped together. Category codes in parentheses are special BFRL codes, as indicated in Appendix A-1 of NAVDOCKS P-72.

[2] Alternative Category Codes are those Navy codes most commonly containing data which, by the IFRS definition, belong under the IFRS code. An individual judgment is required in each case to determine exactly which data listed under the Navy codes belong with the IFRS data.

[3] Indicates the facilities included in the Integrated Facilities Requirements Study, Phase I, ORI TR 520, 5 December 1968.

MODEL DERIVATION

Category Code: 112-10, 112-11, 112-12, (112-80) Facility: Taxiways

Definition of Facility:

Taxiways include all paved areas utilized by aircraft, operating under their own power, to get to and from the takeoff, landing, and parking areas. When a taxiway is contiguous with a parking apron or other paved area, the taxiway width is assumed for planning purposes to remain 75 ft in width, the normal width of a taxiway.

Calculation of Requirement:

The taxiway area requirement of a base is calculated by assuming that all runways presently in existence have adequate taxiways; therefore, new taxiways are required only if new runways are constructed or existing runways are extended in length. Thus, a net taxiway requirement (taxiway deficiency) is computed instead of a gross requirement.

Because of the methodology utilized to generate net runway requirements, upon which taxiway requirements are based, 1/ two different equations were developed to describe the increased taxiway area requirement. The first equation gives the requirement for taxiway area if an existing runway is extended; the second equation gives the area required if a new runway (parallel to an old runway) is built.

If a runway is to be lengthened, the increased taxiway area requirement (in general) is

$$TA_{is}^{tc} = 75\ (L_{is}^{ntc} - L_{is}^{otc}) + 27{,}187\ (N_{is}^{ntc} - N_{is}^{otc}) + 54{,}375 \tag{1}$$

where TA_{is}^{tc} = total increased square feet of taxiway area of thickness t and composition c required for an extension of runway s at base i

L_{is}^{ntc} = new length in feet of runway s of thickness t and composition c at base i

L_{is}^{otc} = old length in feet of runway s of thickness t and composition c at base i

N_{is}^{ntc} = total number of turnoffs of thickness t and composition c required for new runway s at base i

---

1/ The primary assumption is that all new runways will be built parallel to existing runways.

N_{is}^{otc} = total number of turnoffs of thickness t and composition c required for old runway s at base i.

The first term in Equation (1) is the width of a taxiway (75 ft) times the increased length required. The second term is the area per intermediate taxiway turnoff (75 ft wide x 362.5 ft long) times the number of new turnoffs to be built. The third term in Equation (1) is the area of the end taxiway turnoff (150 ft wide x 362.5 ft long). The factor 362.5 given above is the planned estimated distance between the edge of a runway and the edge of its associated taxiway. 2/ The number of turnoffs required for a runway is given in the following tabulation:

Runway Length (ft)	Number of Turnoffs
≤5500	3
5501 to 7500	4
>7500	5

Equation (1) is strictly true only if the extended runway is to be the longest runway in the runway system. If such is not the case, then the first term of Equation (1) drops out and the second and third terms are used to calculate the taxiway area.

If a runway is to be built new, the increase in taxiway area required is

$$TA_{is}^{tc} = 75\ L_{is}^{tc} + 37,500\ (N_{is}^{tc} - 2) + 150,000 \qquad (2)$$

where TA_{is}^{tc} = total increased square feet of taxiway area of thickness t and composition c required for new runway s at base i

L_{is}^{tc} = total length in feet of new runway s of thickness t and composition c at base i

N_{is}^{tc} = total number of turnoffs of thickness t and composition c required for runway s at base i.

The first term in Equation (2) is the length of the new taxiway times its width (75 ft). This term is included only if the runway being built is the first runway in the system. Otherwise it is not included, since it is assumed that it is only necessary to build a complete length of taxiway when none exists. The second term in Equation (2) is the taxiway area required for intermediate taxiway turnoffs (leading to the next runway), (75 x 500), and the last term in Equation (2) is the taxiway area requirements for two end turnoffs (500 x 150 x 2). Again it is assumed that end turnoffs are turnoffs and do not increase the length of the runway.

2/ It is assumed that end taxiway turnoffs are indeed turnoffs and not runway extensions.

The total net taxiway area required is then

$$TA_i^{tc} = \sum_{s=1}^{m} TA_{is}^{tc} \tag{3}$$

where TA_i^{tc} = total increased taxiway area of thickness t and composition c required at base i

m = total number of runways to be extended or built new at base i.

The summation in Equation (3) is taken over all runways to be either extended or built new at base i. As previously indicated, the first term in each of Equations (1) and (2) is used only if the runway is either the longest in the system, or is to be built new.

Source of Calculation:

The above equations were derived using measurement and data from NAVFAC P-80.

Source of Independent Variables:

Taxiway Type to be Built—determined by the Runway Excess/Deficiency calculations which indicate the type of additional runways (if any) to be built

L_{is}^{ntc}, L_{is}^{tc} —determined as described above in the Runway Excess/Deficiency comparison

L_{is}^{otc}, N_{is}^{otc} —data stored in Assets Position Data File

N_{is}^{tc}, N_{is}^{ntc}—selected from the tabulation given above.

MODEL DERIVATION

Category Code: 113-20,113-21,113-22 (113-81)

Facility: Aircraft Parking Apron

Definition of Facility:

Aircraft parking apron area is defined in two distinct categories:

a. Actual aircraft parking apron area including only the area on which aircraft are parked including spacing factors and taxiways between rows and columns but excluding peripheral taxiways

b. Paved peripheral taxiway areas and/or any other miscellaneous paved area surrounding the actual aircraft parking apron.

These two categories are totaled to get total paved aircraft parking area requirements.

Calculation of Requirement:

The actual parking apron area necessary for the parking of aircraft at a naval air station is calculated as follows:

Parking apron depth, including peripheral taxiways, is selected generally in ranges from 675 to 975 ft (with larger values preferred if terrain permits). The depth measurement is that made perpendicular to the runway while apron width is parallel to the runway. The maximum number of aircraft (P_{it}) that can be parked in one row (i.e., column extending the full depth of the apron and perpendicular to the runway) is calculated

$$P_{it} = \text{next highest integer} > \frac{AD_i - B_t}{C_t}$$

where P_{it} = maximum integral number of type t aircraft that can be parked in one row of depth AD_i at base i

AD_i = depth of parking apron (excluding two peripheral taxiways of depth TD_i each) at base i

C_t = depth requirement (including internal taxiway) per aircraft of type t

B_t = depth requirement (excluding internal taxiway) per aircraft of type t.

The smallest integer, P_{it}, for which Equation (1) holds, is then the maximum number of aircraft of type t that can be parked in one row (i.e., column perpendicular to runway) at base i.

Once the number of aircraft per row has been calculated using Equation (1), the number of rows required for all aircraft of type t is determined by the relation

$$R_{it} = \text{Smallest integer} \geq \frac{AC_{it}}{P_{it}} \tag{2}$$

where R_{it} = number of rows required for aircraft of type t at base i

AC_{it} = total number of aircraft of type t to use parking apron at base i

An integral number of rows is used because it is assumed that dissimilar aircraft are not parked in the same row.

The total width of the aircraft parking apron is calculated using the sum of the widths of the total number of rows of each type of aircraft, including the associated taxiways between rows. This width can be minimized by parking aircraft in rows starting with the largest aircraft type and moving down to the smallest aircraft type. The width of the parking apron, assuming this configuration is employed, is

$$W_i = \sum_{t=1}^{n} (A_t + D_t) R_{it} - D_o \tag{3}$$

where W_i = total parking apron width requirement at base i

A_t = width requirement per aircraft of type t

D_t = between aircraft taxiway width requirement per row of aircraft of type t

D_o = taxiway width requirement for the smallest aircraft type to utilize the parking apron

n = number of aircraft types t assigned to base i.

Since P-80 specifies that parking aprons are calculated in increments of 75 ft, the width calculated in Equation (3) is expanded to fill the next full increment of 75 ft; this adjusted width is the required width of the parking apron. Actual parking area required is then

$$APA_i = \frac{1}{9} (AW_i)\ (AD_i) \tag{4}$$

where APA_i = actual square yards of parking apron area required at base i

AW_i = adjusted width in feet of the parking apron at base i

AD_i = depth in feet of parking apron area at base i

1/9 = factor converting square feet to square yards.

Paved peripheral taxiway area is then given by 1/

$$PTA_i = \frac{1}{9}\left[(AW_i + 2TD_i)\ (AD_i + 2TD_i)\right] - APA_i$$

$$= \frac{1}{9}\left[(AW_i + AD_i)\, 2TD_i + 4TD_i^2\right] \tag{5}$$

where PTA_i = square yards of peripheral taxiways required at base i

TD_i = peripheral taxiway width at base i

AW_i, AD_i = as previously defined.

Total parking apron is then

$$PA_i = \frac{1}{9}\,(AW_i + 2TD_i)\ (AD_i + 2TD_i) \tag{6}$$

where PA = total square yards of parking apron required at base i.

Source of Calculations:

The calculation of parking area requirement was derived here following the procedures outlined in the Integrated Facilities Requirements Study, Phase I, and NAVFAC P-80.

Source of Independent Variables:

AD_i —stored in Base Data File

A_t, B_t, C_t, D_t—obtained from NAVFAC P-80 and stored in Aircraft Data File

AC_{it} —data from the Base Loading Submodel and the Base Data File (for Tenant Aircraft)

TD_i —stored in Facilities Requirements Program.

1/ Assuming a rectangular parking area configuration and equal width taxiways on all four sides.

MODEL DERIVATION

Category Code: 124-30 Facility: Aircraft Ready Fuel Storage Tank

Definition of Facility:

Aircraft Ready Fuel Storage Tanks are defined for air installations to be all aviation fuel storage tanks for three fuel types — jet, aviation gas, and helo fuel,[1/] whether the tanks are located on, adjacent to, or remote from the base.

Calculation of Requirement:

The ready fuel storage requirement for each type of fuel on a base depends on three factors: (1) the number of days' supply of fuel required to be stored; (2) the percent of fuel which is lost or unusable due to storage efficiency losses; (3) the annual amount of fuel to be used. The equation expressing these relationships is

$$BFS_{if} = \frac{PF_{if}}{365} (1 + EL_{if}) (BF_{if} + TF_{if}) \qquad (1)$$

where BFS_{if} = ready fuel storage requirement for type f fuel at base i

PF_{if} = number of days' supply of type f fuel required to be stored at base i

EL_{if} = efficiency loss factor for type f fuel at base i

BF_{if} = annual bulk fuel requirements for type f fuel for training aircraft at base i

TF_{if} = annual bulk fuel requirements of type f fuel for all other users at base i.

Since each type of fuel must be stored separately, storage tank requirements must be computed separately for each fuel type. The names of the three types of fuel assumed in the study are (1) jet, (2) aviation gas, and (3) helo.

Source of Calculation:

The calculations of the fuel storage requirement derived above follow the general outline of the derivation in Phase I of the Integrated Facilities Requirements Study.

1/ The model has the capacity to identify separately three different fuel types by sorting on the first letter of the fuel name, i.e., J for jet, A for aviation gas, and H for helo fuel. Helo fuel tanks were separately identified for NAS Whiting; however, most helicopters burn either JP-4 or aviation gas. It was decided to keep the three fuel types in the model so that if and when an additional fuel type is required (e.g., JP-5 for fleet aircraft) by a base, the model can accommodate it.

Source of Independent Variables:

PF_{if} — stored in the Base Data File

EL_{if} — stored in the Base Data File

BF_{if} — data from the Base Loading Submodel

TF_{if} — calculated in the Base Loading Submodel.

MODEL DERIVATION

Category Code: 125-40 — Facility: Distribution Pipeline Underground

Definition of Facility:

Distribution Lines (Fuel) are defined as the total length of pipelines required to distribute fuel from all ready fuel storage facilities at an installation. The requirement is assumed to include provisions for valves, covering, fittings, trenching, backfilling, and cathodic protection when required. Lines may be above or below ground, although the latter is preferred where possible.

Calculation of Requirement:

The estimated miles of fuel distribution pipeline required by a naval air station have been derived using regression analysis to obtain the length of pipe required as a function of the total number of tenants and squadron personnel stationed at a base. The equation expressing this relationship is

$$DP_i = .001375\ (SQ_i + TE_i) \tag{1}$$

where DP_i = miles of distribution pipeline required by base i

SQ_i = total number of squadron personnel on base i including students, instructors, and direct squadron maintenance personnel

TE_i = total number of tenant personnel on base i.

The above equation has a .95 or higher correlation coefficient,and the coefficients are significant with 90 percent confidence per the t test.

Source of Calculations:

In the regression analysis, data was used from the Facilities,Personnel,and Aircraft Summary, Naval Air Training Command, January 1969, and NAVFAC P-164.

Source of Independent Variables:

SQ_i—data from the Base Loading Submodel

TE_i— data stored in the Base Data File.

MODEL DERIVATION

Category Code: 136-30 | Facility: Runway Lighting

Definition of Facility:

Runway lighting is the system of lights defining the usable runway surface including (a) two rows of clear (white) lights marking the side extremities of the runway, (b) green threshold lights marking the ends of the runway, and (c) lighted runway distance markers.

Calculation of Requirements:

The requirement for runway lighting is assumed to be fulfilled unless there is a requirement for a new runway or an extension of present runways as calculated by the runway equations. If a new runway is required, or a runway extended, it is assumed that high intensity lighting will be installed. The expression for the length of runway lighting required is then 1/:

$$R_i = \sum_{s=1}^{n} L_{is} + \sum_{t=1}^{m} E_{it} \qquad (1)$$

where R_i = total feet of runway lighting required at base i

L_{is} = length in feet of each new runway s required to be built at base i

n = total number of runways to be constructed at base i

E_{it} = length of runway extension t to be constructed at base i

m = total number of extensions to be constructed at base i.

The requirement for threshold lighting at the ends of the runways is assumed to be one set for an extended runway (i.e., only one end will be extended) and two sets for a new runway. The total number of thresholds lights required is then

$$TL_i = 2n + m \qquad (2)$$

where TL_i = total number of sets of green threshold lights required at base i.

Total runway lighting requirements are then:

$$R_i + TL_i = \sum_{s=1}^{n} L_{is} + 2n + \sum_{t=1}^{m} E_{it} + m. \qquad (3)$$

1/ Runway lighting is measured in linear feet of runway which takes into account the lighting on each side of the runway.

Source of Calculation:

The runway lighting requirement as derived above uses information in NAVFAC P-80.

Source of Independent Variables:

L_{is}, E_{it}, m, n—derived by the runway methodology.

MODEL DERIVATION

Category Code: 141-40, 141-70

Facility: Aircraft Operations Building With Control Tower

Definition of Facility:

An aircraft operations building and control tower is defined in the IFRS study to be one building including space for the administration of flight operational activities and a control tower providing space for equipment and personnel controlling air traffic.

Calculation of Requirement:

The requirement for an aircraft operations building is assumed to be that for a major training station, including space for a control tower. The requirement is then

Aircraft Operations Building	14,000 sq ft
Control Tower	2,956 sq ft
Total Requirement	16,956 sq ft

Source of Calculation:

Area allowances given are those listed in NAVFAC P-80 and NAVDOCKS P-272.

MODEL DERIVATION

Category Code: 171-10 — Facility: Academic Building

Definition of Facility:

The area required for academic instruction space is defined to include not only classroom space, but also space for administrative offices, assembly rooms, conference rooms, libraries, and lounges. Thus, the requirements for this facility include the gross area for all activities associated with academic instruction.

Calculation of Requirement:

The area required for classroom space at a base is dependent on the total number of students expected to be in class at any one time. The total number of hours spent in class by students of pilot training programs at base i is

$$\sum_{j=1}^{n} (SI_{ij})\ (CH_{ij}) \tag{1}$$

where SI_{ij} = annual student input of students in phase j at base i

CH_{ij} = total number of academic classroom hours (all types) required to train a student at base i in phase j

n = number of training phases at base i.

To obtain the number of students in class at any one time, Equation (1) must be divided by the number of annual hours that classroom space can be utilized for instruction. Thus, the total number of students in class at one time is

$$\sum_{j=1}^{n} \frac{(SI_{ij})\ (CH_{ij})}{CU_i} \tag{2}$$

where CU_i = number of annual hours that classroom space can be utilized for instruction.

The total classroom space requirement must also include provisions for students on base who are not in the pilot training program. The number of these students in class at any one time is derived in a manner similar to that above and is

$$\frac{(TS_i)\ (TH_i)}{CU_i} \tag{3}$$

where TS_i = annual number of students unrelated to a specific training phase requiring instruction at base i

TH_i = number of classroom hours per student of type TS.

The total classroom area required is the total number of students in class at any one time times a space per student factor and is given by

$$CA_i = \sum_{j=1}^{n} \left[\frac{(SI_{ij})\ (CH_{ij})}{CU_i} + \frac{(TS_i)\ (TH_i)}{CU_i} \right] \cdot A$$

where CA_i = total square feet of academic classroom space required at base i

A = gross building area required per student.

Source of Calculations:

The calculation of classroom area is derived above utilizing the basic methodology of the Integrated Facilities Requirements Study, Phase I, and NAVFAC P-80.

Source of Independent Variables:

SI_{ij}—assigned to base in the Base Loading Submodel

CH_{ij}—data stored in the LSR Generator Data File

CU_i—stored in Base Data File

TS_i—stored in Base Data File

TH_i—stored in Base Data File

A—75 ft as specified in NAVFAC P-80.

MODEL DERIVATION

Category Code: 211-10 | Facility: Maintenance Hangar

Definition of Facility:

The requirement for Maintenance Hangars is defined to include space for intermediate and organizational levels of maintenance for aircraft, aircraft spares, and components including hangar, shop, storage, and administrative space. The requirement does not include space for Nose Hangars, Paint and Finishing Hangars, Jet Engine Maintenance Shop, or major rework facilities.

Calculation of Requirement:

Maintenance Hangars are the basic aircraft maintenance facility at a naval air station. In general, maintenance is performed at two levels: the organizational level and the intermediate level. Each level of maintenance has a basic facility assigned to it with the size of the facility depending on the number and type of aircraft on the base. It is assumed that each facility is made up of modular units that may be constructed as separate buildings or incremented in various combinations to provide the necessary space. The two types of maintenance facilities consist of the following modules:

a. Organizational Facility
   1. Hangar Module(s)
   2. Crew and Equipment/Administrative Module(s)

b. Intermediate Facility
   1. Shop Module(s)
   2. Crew and Equipment/Administrative Module(s).

The number of modules required for an organizational facility is determined as follows:

a. Hangar Module: The total number of hangar modules required for each type of aircraft is determined by

$$QH_{it} = \frac{AC_{it}}{MAH_t}$$

where QH_{it} = number of hangar modules required for type t aircraft

AC_{it} = total number of aircraft types t at base i

MAH_t = maximum number of type t aircraft that can be supported by one hangar module.

To obtain the total hangar requirement, the hangar module requirement is summed over all aircraft types.[1] This total is then increased to the next largest integer to account for the modular hangar requirement, which is

$$TH_i = \text{smallest integer} \geq \sum_{t=1}^{n} QH_{it}$$

where TH_i = total number of hangar modules required at base i

n = total number of aircraft types t at base i.

b. Crew and Equipment/Administrative Module. The number of modules required for this category of the organizational facility is determined in a manner similar to the hangar module. The number of modules required is derived as

$$TC_i = \text{smallest integer} \geq \sum_{t=1}^{n} QC_{it} = \sum_{t=1}^{n} \frac{AC_{it}}{MAC_t}$$

where TC_i = total number of crew and equipment/administrative modules required at base i

QC_{it} = number of crew and equipment/administrative modules required for type t aircraft at base i

MAC_t = maximum number of type t aircraft that can be supported by one crew and equipment/administrative module.

The calculation of the requirement for the intermediate facility modules closely parallels that used for the organizational facilities, as follows:

a. Shop Module. The total number of shop modules required is calculated in two stages. First, the number of basic shop modules required is calculated, which is simply the total number of aircraft on a base divided by the number of aircraft (144) that can be supported by one basic module.[2] Thus, the number of basic modules required is

---

1/ This calculation assumes that different types of aircraft can be serviced in the same hangar or facility. If tenant and/or air station aircraft are assigned to a base, it is assumed that the same facilities are used for these tenant aircraft and the training aircraft.

2/ This calculation assumes that a jet engine addition will not be built.

$$QSB_i = \frac{\sum_{t=1}^{n} AC_{it}}{144}$$

where QSB_i = number of basic hangar modules required at base i.

Next, the number of <u>supplementary</u> shop modules required must also be calculated and added to the number of basic shop modules to give total shop modules. This calculation is carried out in the exact manner as the hangar module, i.e.,

$$QSS_i = \sum_{t=1}^{n} \frac{AC_{it}}{MAS_t}$$

where QSS_i = number of supplementary shop modules required at base i

MAS_t = maximum number of type t aircraft that can be supported by one shop module.

The total integral number of shop modules required is then given by

TS_i =(smallest integer $\geq QSB_i$)+ (smallest integer $\geq QSS_i$)

where TS_i = total required shop modules for all aircraft at base i.

b. <u>Crew and Equipment/Administrative Module.</u> In addition to the shop modules, the intermediate level facility requires $\frac{1}{2}$ of a crew and equipment/administrative module. This $\frac{1}{2}$ module is permitted independently of the number of aircraft supported.

Thus, the total number of modules required by a base is the sum of the organizational facility modules and the intermediate facility modules, or

$$TM_i = TH_i + TC_i + TS_i + .5\ TCM$$

where TCM = one crew and equipment/administrative module.

The gross square feet allowed for each module are as follows:

Hangar Module—13,698
Crew and Equipment Module—10,400
Shop Module—8,450.

Thus, the total gross square feet of maintenance hangar requirement are

$$MSF_i = 13,698\ (TH_i) + 8,450\ (TS_i) + 10,400\ (TC_i) + 5,200$$

where MSF_i = total gross square feet of maintenance hangar required at base i.

Source of Calculations:

The calculation of the Maintenance Hangar requirement as outlined here utilizes the methodology outlined in NAVFAC P-80.

Source of Independent Variables:

AC_{it}—assigned to a base in the Base Loading Submodel; tenant aircraft data are in the Base Data File.

MAH_t, MAC_t, MAS_t—data in the Aircraft Data File.

MODEL DERIVATION

Category Code: 219-10

Facility: Public Works Maintenance Shop

Definition of Facility:

The Public Works Maintenance Shop is defined to include space for the equipment and personnel required to maintain, repair, and overhaul installation facilities. Included within the definition is space for a woodworking shop, electric shop, plumbing and heating shop, metal work shop, paint shop, routine maintenance and service shop, and administrative office space.

Calculation of Requirement:

The calculation of the area required for a public works maintenance shop depends on the number of maintenance personnel on a base, which in turn is dependent on the total number of personnel (both military and civilian) at a base. Thus, the total number of maintenance personnel is derived by regression analysis and is given by the equation:

$$PWC_i = 75.78 + .0459\,(SQ_i + TE_i) \tag{1}$$

where PWC_i = number of public works personnel at base i

SQ_i = total number of squadron personnel at base i

TE_i = total number of tenant personnel at base i.

The number of PWC personnel is then used in conjunction with the following tabulation to determine total floor area requirements.

Total Maintenance Personnel	Max. Total Floor Area, gross sq ft
0-100	5,800
101-200	10,900
201-300	15,500
301-400	19,500
401-500	22,900
501-600	25,700

Note that straight line interpolation is used to calculate intermediate numbers not listed above, as directed by NAVFAC P-80.

Source of Calculations:

Total base personnel and base maintenance personnel data for the regression analysis described above were obtained from Facilities, Personnel, and Aircraft Summary. The previous tabulation is given in NAVFAC P-80.

Source of Independent Variables:

SQ_i—assigned in the Base Loading Submodel

TE_i—data in the Base Data File.

MODEL DERIVATION

Category Codes: 442-10, 442-20, 442-30, 442-60, 442-65, 442-90

Facility: Covered Storage, Ready Issue

Definition of Facility:

Covered Storage is defined in this study to cover two different types of structures: warehouse and shed. The facility definition includes space for all ready issue storage such as controlled humidity warehouse, hazardous and flammables storehouse, aviation warehouse, clothing and small stores, and miscellaneous storage. Excluded from the definition are bulk, perishable subsistence, transit, public works maintenance, and ground handling equipment storage.

Calculation of Requirement:

The total ready issue covered storage requirement for a naval air station is a function of both the number and type of aircraft at that station and the total number of base personnel. For purposes of requirement calculations, covered storage space is divided into warehouse space and shed space. The total amount of warehouse space needed can be expressed as

$$TW_i = \sum_{t=1}^{n} \nu_t AC_{it} + \sum_{e=1}^{4} \Psi_e NM_{ie} \qquad (1)$$

where TW_i = total square feet of warehouse space required at base i

ν_t = warehouse space allowance per aircraft for type t aircraft

AC_{it} = number of type t aircraft at base i

Ψ_e = warehouse space allowance per person within base population group e

NM_{ie} = number of people within population group e at base i.

Similarly, the total amount of covered shed space required can be expressed as

$$TS_i = \sum_{t=1}^{n} \gamma_t AC_{it} + \sum_{e=1}^{4} \kappa_e NM_{ie} \qquad (2)$$

where TS_i = total square feet of shed space required at base i

γ_t = shed space allowance per aircraft for type t aircraft

AC_{it} = number of type t aircraft at base i

κ_e = shed space allowance per person within base population group e.

The total gross covered storage requirement for base i is then

$$TSC_i = 1.018TW_i + 1.015TS_i \qquad (3)$$

where TCS_i = total gross square feet of covered storage required at base i.

Note that the numbers 1.018 and 1.015 are structural space allowance factors for warehouses and sheds, respectively.

Source of Calculations:

The calculations described here follow the methodology suggested in NAVFAC P-80 for calculating total covered storage requirements for a naval air station. All calculations start with population group 1 and proceed to group 4 as necessary.

Source of Independent Variables:

υ_t, γ_t—data in the Aircraft Data File

AC_{it}—assigned to a base in the Base Loading Submodel; tenant aircraft data are in Base Data File

NM_{ie}, Ψ_e, δ_e—calculated using total base personnel as assigned to a base in the Base Loading Submodel and the Base Data File and the following tabulation.

Personnel Space Allowance Factors, Ψ_e, δ_e
(as a function of Population Groups)

Population Group (e)	Base Personnel in Population Group	Space Allowance per person, sq ft	
		Warehouse (Ψ_e)	Shed (δ_e)
1	1-4,000	15	2.0
2	4,001-6,000	10	1.5
3	6,001-8,000	5	0.5
4	8,001+	3	0.0

See Table E.3, line 9, for aircraft spacing factors included in the model.

MODEL DERIVATION

Category Code: 550-10, 550-20 Facility: Dispensary With and Without Beds

Definition of Facility:

A dispensary is defined as a medical treatment facility that is primarily intended to provide examination and treatment of ambulatory patients, to make arrangements for transfer of patients to hospitals, and to render first aid in emergency cases. A dispensary may or may not include space for beds.

Calculation of Requirement:

The space required for a dispensary is assumed for planning purposes to be a function of total installation military strength including military dependents, i.e., total number of eligible personnel. Assuming the average family size is 2.5,[1/] including the head of the household, the total number of eligible personnel is calculated by

$$IP_i = 2.5\,(C_iNO_i + D_iSL_i) + NO_i + SL_i + 2.5EM_i\,(A_iB_i + E_i\,(1-A_i)) + EM_i \quad (1)$$

where IP_i = total installation population eligible for dispensary privileges at base i

C_i = average fraction of all officers (excluding students in pilot training) requiring family housing at base i

NO_i = total number of officers (excluding pilot trainees) at base i

D_i = fraction of pilot students at base i requiring family housing

SL_i = average pilot student load at base i

EM_i = total number of enlisted men at base i

A_i = fraction of enlisted men at base i eligible for family housing

B_i = fraction of eligible enlisted men requiring family housing at base i

E_i = fraction of ineligible enlisted men requiring family housing at base i.

The dispensary space required is calculated for two cases: dispensaries with and without beds. For dispensaries with beds, the required floor area is

---

1/ Average U.S. family factor as noted in NAVFAC P-80.

$$TD_i^b = 3.696\ IP_i \qquad (2)$$

where TD_i^b = total square feet of dispensary space with beds at base i.

For dispensaries without beds, the required floor area is

$$TD_i^{nb} = 3.08\ IP_i \qquad (3)$$

where TD_i^{nb} = total square feet of dispensary space without beds at base i.

The planning factors of 3.696 and 3.08 were developed from data in NAVFAC P-80.

Source of Calculation:

The data and methodology used here were taken from NAVFAC P-80.

Source of Independent Variables:

NO_i, SL_i, EM_i—assigned to a base in the Base Loading Submodel

A_i, B_i, C_i, D_i, E_i—data in the Base Data File.

MODEL DERIVATION

Category Code: 610-10 Facility: Administrative Office

Definition of Facility:

Administrative office space is defined as the area containing the offices of the commanding officer, the executive and administrative officers, and the space for military and civilian personnel required to carry the administrative workload of the activities of a base. It includes space for offices, business machines, records, files, administrative supplies,and other activities associated with normal base operations. However it does not include the administrative space located in maintenance hangars, warehouses or other buildings, but only the spaces utilized by administrative personnel engaged in administration of general base activities.

Calculation of Requirement:

The space allowance for Administrative Offices is 162 sq ft per occupant of the facilities; thus, the total requirement for administrative office space can be expressed as

$$AO_i = 162\ (FA_i)\ (TBP_i) \tag{1}$$

where AO_i = total square feet of central administrative office space required at base i

FA_i = fraction of total personnel at base i engaged in administration and occupying a central administrative facility

TBP_i = total number of personnel at base i including NAS, tenant, and squadron personnel.

Source of Calculation:

The calculation outlined above is given in NAVFAC P-80.

Source of Independant Variables:

FA_i—stored in the Base Data File

TBP_i—calculated in the Base Loading Submodel as the sum of all squadron, NAS, and tenant personnel.

MODEL DERIVATION

Category Code: 711-10 through 62

Facility: Family Housing (Officers and Eligible Enlisted)[1]

Definition of Facility:

Family housing in this category is defined to be required for all eligible military personnel (including students) with dependents. No distinctions are made between housing types or housing unit sizes. Housing requirements are defined to be fulfilled by either military owned or military occupied housing. Thus, facility requirements can be fulfilled by privately owned housing units or military units.

Calculation of Requirement:

Family housing for eligible base personnel is divided into officer and enlisted housing. The total amount of officer housing required at a base is given by

$$FHO_i = (C_i)(NO_i) + (D_i)(SL_i) \qquad (1)$$

where FHO_i = total number of units of family housing required for officers at base i

C_i = average fraction of all officers (excluding students in pilot training) requiring family housing at base i

NO_i = total number of officers excluding pilot trainees at base i

D_i = fraction of pilot students at base i requiring family housing

SL_i = average student load at base i. [2]

The total number of units of eligible enlisted housing required at a base is

$$FHE_i = (A_i)(B_i)(EM_i) \qquad (2)$$

1/ Eligible enlisted personnel are all those of rank E-4 with 4 or more years service and all those of rank E-5 or above.

2/ It is assumed that students in pilot training will require family housing regardless of the length of time they spend at one base.

where FHE_i = total number of units of family housing required for eligible enlisted men at base i

A_i = fraction of enlisted men at base i eligible for family housing

B_i = fraction of eligible enlisted men requiring family housing at base i

EM_i = total number of enlisted men at base i.

Hence, the total number of housing units required for all officers and eligible enlisted personnel at a base is

$$TFH_i = FHE_i + FHO_i \tag{3}$$

where TFH_i = total number of family housing units required at base i for all eligible personnel.

Source of Calculation:

The calculations described here use the basic methodology of IFRS, Phase I. In addition, the methods for calculating family housing shown in NAVFAC P-80 and "Determination of Family Housing Requirements" (DD Form 1378) were consulted.

Source of Independent Variables:

A_i, B_i, C_i, D_i—data in the Base Data File as obtained from DD Form 1378

NO_i—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File

SL_i—assigned to a base in the Base Loading Submodel

EM_i—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File.

MODEL DERIVATION

Category Code: None

Facility: Family Housing (Ineligible Enlisted)

Definition of Facility:

Family housing in this category is defined to be required for ineligible military personnel[1/] with dependents. No distinctions are made between housing types or housing unit sizes. Housing requirements are defined to be fulfilled by either military owned or military occupied housing. Thus, facility requirements can be fulfilled by privately owned housing units.

Calculation of Requirement:

In addition to personnel eligible for family housing, ineligible personnel are sometimes provided family housing. The current calculation permits an estimate of the family housing requirement for ineligible personnel independently of the eligible personnel, as follows:

$$FHIE_i = (1 - A_i)(E_i)(EM_i) \tag{1}$$

where $FHIE_i$ = total number of units of ineligible family housing required at base i

A_i = fraction of enlisted men at base i eligible for family housing

E_i = fraction of ineligible personnel requiring family housing at base i

EM_i = total enlisted personnel at base i.

Source of Calculation:

The basic methodology of IFRS, Phase I was used in this calculation. In addition, the methods for calculating family housing used in NAVFAC P-80 and DD Form 1378 were consulted.

Source of Independent Variables:

A_i, E_i—data in the Base Data File

EM_i—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File.

1/ Ineligible personnel are enlisted men of rank E-4 with 3 years or less in the service and all those of rank E-3 and below.

MODEL DERIVATION

Category Code: 722-10

Facility: Enlisted Men's Barracks Without Mess

Definition of Facility:

Enlisted men's barrack requirements are defined to include public housing for bachelor enlisted personnel, both male and female, permanently stationed at a base. The available number of billets includes facilities with/or without mess, but new facilities (if any) are assumed to be constructed without mess.

Calculation of Requirement:

Enlisted men's barracks are assumed to be provided for all enlisted men not requiring family housing. The total fraction of eligible enlisted men requiring family housing has previously been derived as $(A_i)(B_i)$, while the total fraction of ineligible enlisted men requiring family housing was given as $(1 - A_i)(E_i)$

where A_i = fraction of enlisted men at base i eligible for family housing

B_i = fraction of eligible enlisted men requiring family housing

E_i = fraction of ineligible enlisted men requiring family housing.

The total number of enlisted men's billets required is then given by the equation[1/]

$$TBEM_i = \{1 - [(A_i)(B_i) + (1 - A_i)(E_i)]\} EM_i$$

where $TBEM_i$ = total number of billets for enlisted men required at base i

EM_i = total number of enlisted men at base i.

Source of Calculation:

The above calculation utilized the methodology developed in IFRS, Phase I and DD Form 1378.

Source of Independent Variables:

A_i, B_i, E_i—data in the Base Data File

EM_i—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File.

1/ This calculation assumes that ineligible enlisted men with families will live in family housing. It also assumes that all enlisted men not living with dependents will live in the prescribed barracks.

MODEL DERIVATION

Category Code: 723-10 Facility: Mess Hall

Definition of Facility:

Mess hall space allowances are defined to include the total area required for a cafeteria type dining facility including food storage space, kitchen space, serving space, and dining space. Excluded is space required for heating, mechanical, and electrical heating equipment.

Calculation of Requirement:

Category 723-10 includes mess facilities for enlisted men on the base. The total mess hall capacity required is

$$TMHC_i = MH_i (TBEM_i) \tag{1}$$

where $TMHC_i$ = total enlisted men's mess hall capacity required at base i

$TBEM_i$ = total enlisted men's barrack capacity at base i

MH_i = fraction of total enlisted mess barrack capacity utilizing mess facilities.

The total floor area required for dining facilities is then

$$TMHA_i = FA (TMHC_i) \tag{2}$$

where $TMHA_i$ = total gross square feet of floor area required for dining facilities at base i

FA = floor area allowance in square feet per person as listed in the following table.

DINING AREA FACILITY FACTORS[1/]

Total Mess Hall Capacity ($TMHC_i$)	Gross Floor Area per Person, sq ft (FA)
0-50	34.5
51-150	23.0
151-500	17.0
501-750	15.0
751-1,250	15.0
1,251-2,250	11.0
> 2,250	10.0

[1/] The gross floor area factors are average values for dining facilities providing storage for 2 to 4 days' subsistence as listed under "Type A," p. 720-6 of NAVFAC P-80.

Source of Calculation:

The requirement derived here utilized the methodology in NAVFAC P-80.

Source of Independent Variables:

$TBEM_i$—calculated in the Facilities Requirements Submodel for Category Code 722-10.

MH_i—data in the Base Data File.

MODEL DERIVATION

Category Code: 724-15 Facility: BOQs Without Mess

Definition of Facility:

Bachelor officers' quarters are defined to include billets for the installation's bachelor officer strength including male and female officers, officer students, transients, and/or rotational officer personnel. Phase,tenant and NAS officers are included within total requirements.

Calculation of Requirement:

The calculation of the requirement for BOQs assumes that all new BOQs will be planned without mess facilities. The calculation further assumes that all officers (and students) not utilizing family housing require billets on base. The total number of billets required is then

$$TBOQ_i = (1 - C_i)(NO_i) + (1 - D_i)(SL_i) \qquad (1)$$

where $TBOQ_i$ = total number of bachelor officers' quarters billets required at base i

C_i = fraction of officers (excluding students in pilot training programs) requiring family housing at base i

NO_i = total number of officers (excluding students in pilot training programs) at base i

D_i = fraction of students in pilot training programs requiring family housing at base i

SL_i = average student load at base i.

Source of Calculation:

Equation (1) was derived following the methodology in IFRS, Phase I, and DD Form 1378.

Source of Independent Variables:

SL_i, NO_i—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File.

C_i, D_i—data in the Base Data File.

MODEL DERIVATION

Category Code: 740-14 Facility: Exchange

Definition of Facility:

The components of the "standard" IFRS Exchange are listed below. Space allowance factors for the Exchange include space for sales area, stock area, officers, toilets, and entrance facilities, but excludes space for an exchange warehouse.

Calculation of Requirement:

For this study, a standard exchange has been defined to include the following facilities:

- Main Retail Store
- Exchange Cafeteria
- Exchange Maintenance Shop
- Barber Shop
- Exchange Central Administrative Facility.

Each of these facilities has a floor area associated with it; its size depends on the military strength of the base. The sum of all these facility floor areas is assumed to be the total floor area requirement for an exchange (see the following table).

EXCHANGE FLOOR AREA REQUIREMENT

Base Military Strength	Floor Area, gross sq ft
0-500	4,900
501-1,000	7,720
1,001-3,000	13,680
3,001-5,000	17,530
5,001-7,000	22,530
7,001-10,000	24,880
10,001-15,000	30,530
15,001-20,000	39,440
20,001-25,000	43,440
25,001-30,000	45,890

Straight line interpolation is used to obtain intermediate numbers not listed above per NAVFAC P-80 guidance (i.e., a specific floor area is calculated for each base strength).

Source of Calculation:

Data used to construct the foregoing table are tabulated in NAVFAC P-80.

Source of Independent Variables:

Base Military Strength—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File.

MODEL DERIVATION

Category Code: 740-63

Facility: Enlisted Men's Service Club

Definition of Facility:

An Enlisted Men's Service Club space allowance is defined to include all facilities within the club including the bar, eating facilities, toilets, etc.

Calculation of Requirement:

The size of an Enlisted Men's Service Club depends on the total number of of enlisted men stationed at a base. The floor area requirement for the club at a base is calculated using the following table.

BUILDING AREA OF ENLISTED MEN'S SERVICE CLUB

Total Enlisted Strength	Gross Building Area, sq ft
< 250	10 sq ft per person
251- 500	3,000
501- 750	7,000
751- 1,200	10,000
1,201- 2,000	12,700
2,001- 4,000	19,800
4,001- 5,000	27,800
> 5,000	27,800 per 5,000 persons

Straight line interpolation is used to obtain the exact requirement for each base.

Source of Calculation:

The methodology used here utilized data listed in NAVFAC P-80.

Source of Independent Variables:

Total Enlisted Strength—assigned to a base in the Base Loading Submodel; tenant data are from the Base Data File

MODEL DERIVATION

Category Code: 812-30

Facility: Distribution Line (Electrical)

Definition of Facility:

Distribution lines are defined to include all lines connecting power sources to consuming facilities. The power sources may be off base or a reserve generator equipment on base. Both overhead and underground distribution lines are included in the definition. Distribution lines within 5 feet of a source or consuming facility are not included, as they are defined as a part of the facility.

Calculation of Requirement:

The length of electrical distribution line required by a base is estimated by regression analysis to be

$$EDL_i = 54.9\,(SQ_i + TE_i) \qquad (1)$$

where EDL_i = total feet of electrical distribution line required at base i

SQ_i = total number of squadron personnel on base i

TE_i = total number of tenant personnel at base i.

The above equation has a .95 or higher correlation coefficient,and the coefficients are significant with 90 percent confidence per the t test (see Appendix K.)

Source of Calculation:

The regression analysis used data from NAVFAC P-164 (Individual Base Real Property Inventories) and Facilities, Personnel, and Aircraft Summary.

Source of Independent Variables:

SQ_i—assigned to a base in the Base Loading Submodel

TE_i—data in the Base Data File.

MODEL DERIVATION

Category Code: 842-10 Facility: Water Distribution Line (Potable)

Definition of Facility:

Water Distribution Lines are defined to include all lines from a storage tank or a treatment plant to station demand points. The storage tank or treatment plant may be on or off base. Distribution lines within 5 feet of a facility are not included, as they are defined to be a part of that facility.

Calculation of Requirement:

The length of a Water Distribution Line required by a base is estimated by regression analysis to be

$$WDL_i = -76{,}400 + 40.5\ (SQ_i + TE_i) + 105\ (SL_i) \qquad (1)$$

where WDL_i = total feet of water distribution line required at base i

SQ_i = total number of squadron personnel at base i

TE_i = total number of tenant personnel at base i

SL_i = average student load at base i.

The above equation has a .95 or higher correlation coefficient, and the coefficients are significant with 90 percent confidence per the t test (see Appendix K).

Source of Calculation:

The regression analysis used data from NAVFAC P-164 and Facilities, Personnel, and Aircraft Summary.

Source of Independent Variables:

SQ_i, SL_i—assigned to a base in the Base Loading Submodel

TE_i—data in the Base Data File.

MODEL DERIVATION

Category Code: 851-10,851-11,851-12 (851-80)   Facility: Roads

Definition of Facility:

The Road requirement is defined to encompass roads of all types including primary (major traffic arteries), secondary (access roads with a moderate traffic volume), and tertiary roads (providing access to individual buildings or groups of buildings). The requirement includes roads on the grounds of activities and non-contiguous areas.

Calculation of Requirement:

The total miles of roads required at a base are estimated by regression analysis to be

$$MR_i = -11.5 + .0224\,(EMS_i + TEM_i) \tag{1}$$

where MR_i = total miles of roads required at base i

EMS_i = total squadron enlisted men at base i

TEM_i = total enlisted tenants at base i.

The above equation has a .95 or higher correlation coefficient, and the coefficients are significant with 90 percent confidence per the t test (see Appendix K).

Source of Calculation:

The regression analysis used data from NAVFAC P-164 and Facilities, Personnel, and Aircraft Summary.

Source of Independent Variables:

EMS_i —assigned to a base in the Base Loading Submodel

TEM_i —data in the Base Data File.

MODEL DERIVATION

Category Code: 852-10,852-11,852-12 (852-80)

Facility: Auto Parking Areas

Definition of Facility:

The requirement for Parking Areas is defined to include all parking areas at a base for off-street parking of passenger cars and trucks, both organizational and nonorganizational, including parking areas located on the ground of activities and noncontiguous areas. Area allowances include space for parking and for paved access and exit areas.

Calculation of Requirement:

The total Parking Area required at a base is estimated by regression analysis to be

$$PA_i = .155\,(EMS_i + TEM_i)^{1.824} \tag{1}$$

where PA_i = total parking area in square yards required at base i

EMS_i = total squadron enlisted men at base i

TEM_i = total enlisted tenants at base i.

The above equation has a .95 or higher correlation coefficient, and the coefficients are significant with 90 percent confidence per the t test (see Appendix K).

Source of Calculation:

The regression analysis used data from NAVFAC P-164 and Facilities, Personnel, and Aircraft Summary.

Source of Independent Variables:

EMS_i —assigned to a base in the Base Loading Submodel

TEM_i —data in the Base Data File.

APPENDIX E

BASE AND AIRCRAFT DATA FILES

BASE DATA FILE

E.1 The purpose of the Base Data File is to store pertinent base-specific data required in the calculations of the Base Loading Submodel and the Facilities Requirements Submodel. The Data File is divided into nine separate parts, one for each of the eight bases under study and one for the new, or phantom, base. The data stored are, in general, unique for each base, although some data may be the same for two or more bases. This permits one item of data to be accessed several times as required (e.g., family housing factors are required in several equations).

Description of the Data File

E.2 Table E.1 presents the data presently contained in the Base Data File for each of the nine bases. These data are subject to modification as required but represent the most accurate and up-to-date data available at the present time. The sources for the data, together with a brief description of each type of data are given below. Numbers under which data are listed are keyed to the numbers on the left hand column of Table E.1.

1. Parking Apron Depth — The depth in feet of the actual parking apron area at each NAS. This number was derived by taking the total depth of apron pavement and subtracting a 300-ft allowance for peripheral taxiways. In cases where parking apron area was not rectangular, an "equivalent" apron depth was derived. Source: Master Development Plans for Chase and Corpus Christi; General Development Maps for other bases.

TABLE E.1

BASE DATA FILE*

	NAS	CHAS	CØRP	ELLY	KING	MERI	PENS	SAUF	WHIT	PHAN
1.	PARKING APRØN DEPTH	250.	600.	1200.	300.	700.	420.	470.	450.	450.
2.	DAYS ØF READY FUEL STØRAGE:									
	JET	10.	10.	10.	10.	10.	10.	10.	10.	10.
	AGAS	10.	10.	10.	10.	10.	10.	10.	10.	10.
	HELØ	10.	10.	10.	10.	10.	10.	10.	10.	10.
3.	FUEL LØSS FACTØRS:									
	JET	.11	.11	.11	.11	.11	.11	.11	.11	.11
	AGAS	.11	.11	.11	.11	.11	.11	.11	.11	.11
	HELØ	.09	.09	.09	.09	.09	.09	.09	.09	.09
4.	ANNUAL CLASS UTILIZ.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.
	TENANT DATA:									
5.	ANNUAL CLASS HRS	0.	0.	0.	0.	0.	0.	0.	0.	0.
6.	STUDENTS	0.	0.	0.	0.	6.	0.	0.	0.	0.
	ØFFICERS	0.	239.	0.	0.	6.	529.	0.	2.	0.
	ENLISTED	0.	890.	0.	0.	9.	954.	0.	26.	0.
	CIVILIAN	0.	4592.	0.	0.	0.	6220.	0.	16.	0.
	HØUSING DATA:									
7.	%ELLIGIBLE ENLISTED	.419	.513	.422	.461	.482	.422	.422	.477	.450
8.	%ENL. REQ. HØUSING	.825	.797	.724	.754	.885	.724	.724	.762	.780
9.	%ØFF. REQ. HØUSING	.835	.816	.847	.850	.873	.847	.847	.834	.840
10.	%STU. REQ. HØUSING	.254	.538	.569	.469	.342	.569	.569	.476	.470
11.	%INELLIG. ENLISTED	.204	.225	.179	.237	.201	.179	.179	.247	.210
12.	MESS HALL FACTØR	.85	.85	.85	.85	.85	.97	.83	.85	.85
13.	DISPENSARY 1=W/BEDS	1	1	1	1	1	0	0	1	1
14.	%BASE REQ. ADMIN ØFF	.10	.12	.10	.10	.10	.15	.10	.10	.10
15.	ALT-TEMP CØRRECTIØN	.26	.19	.19	.23	.26	.19	.19	.23	.
16.	WINDRØSE DATA MAIN	.84	.84	.90	.92	.90	.90	.90	.90	.90
17.	CRØSSWIND	.09	.16	.10	.08	.10	.10	.10	.10	.10
18.	TENANT A/C VF	0.	11.	0.	0.	0.	20.	0.	0.	0.
	VT	2.	14.	2.	2.	2.	19.	2.	1.	2.
	VR	0.	0.	0.	0.	0.	8.	0.	0.	0.
	VØ	0.	0.	0.	0.	0.	1.	0.	0.	0.
	VW	0.	0.	0.	0.	0.	1.	0.	0.	0.
	H	2.	3.	0.	2.	2.	5.	0.	0.	2.

* As of 1 January 1970.

2. Days of Ready Fuel Storage— The number of days of ready fuel storage required at each NAS for each of the three fuel types (Jet, Avgas, Helo). Source: NAVFAC P-80, p. 120-12.

3. Fuel Loss Factor— The fraction of fuel held in ready fuel storage which is unusable due to losses because of evaporation, seepage, etc. Source: IFRS, Phase I, p. 89.

4. Annual Class Utilization— The average number of hours per year that academic classrooms can be utilized for instruction. Source: These factors were tentatively derived assuming that classrooms could be used 8 hr per day and 250 days per year or 2000 hr.

5. Tenant Data: Annual Class Hours— The average number of hours annually that each tenant student spends in an academic classroom. Source: At present no data are available for these factors.

6. Tenant Data: Students, Officers, Enlisted, Civilian—The number of tenants at each base subdivided by rank and type (military or civilian). Source: Naval Air Training Command, Facilities, Personnel, and Aircraft Summary, January 1969, pp. 2,3,6,10,14,19,23,26,30.[1/] (Unofficial publication.)

7. Housing Data: Percentage Eligible Enlisted—The fraction of total enlisted men (including tenants) at each NAS who are eligible for family housing. Source: DD Form 1378, 31 January 1968, authenticated by F.W. Hirsh, Head, Program Development Branch; derived from data on Line 2 of Form.

8. Housing Data: Percentage Enlisted Requiring Housing—The fraction of eligible enlisted men requiring family housing. Source: DD Form 1378, Line 3.

9. Housing Data: Percentage Officer Requiring Housing—The fraction of total officers (excluding pilot training students) at each NAS requiring family housing. Source: DD Form 1378, Line 3.

10. Housing Data: Percentage Students Requiring Housing—The fraction of total pilot training students at each NAS requiring family housing. Source: DD Form 1378, Line 3.

[1/] Personnel of the USS Lexington and USS Kingbird were not included as tenants of NAS Pensacola.

11. Housing Data: Percentage Ineligible Enlisted— The fraction of total ineligible enlisted men requiring family housing. Source: DD Form 1378, Line 3.

12. Mess Hall Factor— The fraction of total enlisted men's barrack capacity which is planned to be fed by the enlisted men's mess hall at each NAS. Source: NAVFAC P-80, p. 720-5; data obtained from NAS Pensacola for NAS Pensacola and NAS Saufley.

13. Dispensary: Code indicating for each NAS, whether their present dispensary has beds. 1 means it has beds, 0 means it does not. Source: NAVFAC P-164, Vol. 2, pp. 1842, 1961, 1971, 1976, 1940; Vol. 3, pp. 2556, 2595, 2609.

14. Percentage Base Requiring Administrative Offices— The fraction of total base personnel (both military and civilian) requiring administrative office space in a central administrative facility. Source: Data obtained from NAS Pensacola for Pensacola and estimates by personnel at NAVFAC, Washington, D.C., for other bases.

15. Altitude-Temperature Correction— The correction factor for runway length taking into account the altitude and mean summer day temperature of each NAS. Source: NAVFAC P-80, pp. 110-5, 110-6. (Currently not used in model.)

16. Wind Rose Data, Main—The fraction of time the main runway(s) at each NAS are usable for tricycle landing gear aircraft (15-knot or less beam wind component). Source: General Development Maps.

17. Wind Rose Data, Crosswind— The fraction of time the crosswind runway(s) at each NAS are usable for tricycle landing gear aircraft (15-knot or less beam wind component). Source: General Development Maps.

18. Tenant Aircraft— The number of each type of aircraft utilized by tenants at each NAS. (For definitions of which aircraft are in which category see page E-10 of this appendix). Source: Facilities, Personnel, and Aircraft Summary, pp. 4, 6, 11, 15, 19, 23, 27, 31. (Unofficial publication.)

The data contained in the phantom base data file are estimates by ORI. In general, these estimates were derived using averages of the data for the other eight naval air stations.

AIRCRAFT DATA FILE

E.3 The purpose of the Aircraft Data File is to store aircraft-related data utilized in the Facilities Requirements Submodel, the Base Loading Submodel, the Aircraft Investment Cost calculations and the Runway calculations. The Data File actually consists of separate data files, one for each type of aircraft, for up to 15 different types of training aircraft and six types of tenant and NAS aircraft.

E.4 The data contained in the Aircraft Data File are listed in Table E.2 for the 10 aircraft types utilized for the present pilot training program and in Table E.3 for six types of tenant aircraft. As indicated in the tables, the types of data stored vary slightly, depending on whether the aircraft are phase or tenant aircraft. A description of each item of data and its source is given below for all data in the Aircraft Data File. The numbers given below correspond to the numbers appearing in the left hand columns of Tables E.2 and E.3.

1. Parking Apron Data A— The length in feet of each aircraft type. Source: NAVFAC P-80, Figure 11-5, p. 110-21.[2/]

2. Parking Apron Data B— The wingspan in feet of each aircraft type. Source: NAVFAC P-80, Figure 11-5, p. 110-21.[2/]

3. Parking Apron Data C— The total depth of parking apron occupied by each aircraft type including aircraft wingspan and a spacing allowance between aircraft. Source: NAVFAC P-80, Figure 11-5, p. 110-21.[2/]

4. Parking Apron Data D— The width of the internal taxiways (distance between aircraft rows) in a parking apron for each aircraft type. Source: NAVFAC P-80, Figure 11-5, p. 110-21.[2/]

5. Aircraft per Hangar Module—The maximum number of aircraft of each type that can be serviced by one hangar maintenance module. Source: NAVFAC P-80, Table 21-4, p. 210-8.

2/ The parking apron factors for the TS-2A were obtained from the Master Development Plans for NAS Corpus Christi.

TABLE E.2

AIRCRAFT DATA FILE—TRAINING AIRCRAFT DATA*

	TRAINING A/C	UNIT	T34B	T28C	T-2A	T2BC	TF9J	TA4J	TS2A	THIL	TH57	H-34
1.	PARKING APRØN DATA A	FT	25.8	34.5	35.5	35.5	34.5	31.0	34.0	53.0	43.3	65.8
2.	PARKING APRØN DATA B	FT	32.8	40.6	35.5	35.5	34.5	31.0	35.0	44.0	37.3	56.2
3.	PARKING APRØN DATA C	FT	47.8	55.6	68.0	68.0	68.0	53.2	46.0	88.0	74.5	84.2
4.	PARKING APRØN DATA D	FT	72.8	80.6	90.0	90.0	90.0	90.0	50.0	132.0	111.8	112.0
5.	A/C PER HANGAR MØDULE	AC	24.	24.	24.	24.	15.	15.	15.	16.	16.	12.
6.	A/C PER CREW & EQUIP MDL	AC	48.	48.	48.	48.	24.	24.	24.	24.	24.	20.
7.	A/C PER BASIC SHØP MDL	AC	144.	144.	144.	144.	144.	144.	144.	144.	144.	114.
8.	A/C PER SUPPL SHØP MDL	AC	96.	96.	96.	96.	60.	60.	60.	48.	48.	24.
9.	CØVERED WAREHØUSE SPACE	SF	175.	175.	375.	375.	400.	400.	400.	175.	175.	250.
10.	SHED SPACE REQUIRED	SF	5.	5.	8.	8.	8.	8.	8.	5.	5.	8.
11.	ØPEN STØRAGE REQUIRED	SF	50.	50.	110.	110.	115.	115.	115.	0.	50.	75.
12.	RUNWAY LENGTH REQ.	LF	3000.	5000.	5000.	5000.	8000.	8000.	8000.	200.	200.	200.
13.	RUNWAY LØAD FACTØR	**	1.	1.	1.	1.	3.	2.	2.	1.	1.	1.
14.	RUNWAY CØMPØSITIØN FACT.	**	2.	2.	1.	1.	1.	1.	1.	2.	1.	2.
15.	INVESTMENT CØST (THØU.)	$$	40.	500.	600.	600.	1100.	1100.	2000.	400.	115.	400.
16.	Ø&M CØST PER FLIGHT HØUR	$$	4.60	8.73	29.70	43.91	17.56	37.68	33.39	10.30	10.90	10.30
17.	INVENTØRY	UN	150.	469.	114.	178.	399.	100.	179.	0.	34.	86.

* As of 1 January 1970.

TABLE E.3

AIRCRAFT DATA FILE—TENANT AND NAS AIRCRAFT DATA*

	TENANT A/C	UNIT	VF	VT	VR	VØ	VW	H
1.	PARKING APRØN DATA A	FT	34.5	35.5	93.9	27.7	40.0	52.2
2.	PARKING APRØN DATA B	FT	34.5	35.5	117.5	37.2	50.0	44.0
3.	PARKING APRØN DATA C	FT	67.9	68.0	137.5	57.2	65.0	66.0
4.	PARKING APRØN DATA D	FT	90.0	90.0	157.5	77.2	90.0	110.0
5.	A/C PER HANGAR MØDULE	AC	15.	24.	6.	24.	6.	12.
6.	A/C PER CREW & EQUIP MDL	AC	24.	48.	12.	48.	12.	20.
7.	A/C PER BASIC SHØP MDL	AC	144.	144.	144.	144.	144.	144.
8.	A/C PER SUPPL SHØP MDL	AC	60.	96.	24.	96.	12.	24.
9.	CØVERED WAREHØUSE SPACE	SF	375.	375.	350.	175.	900.	250.
10.	SHED SPACE REQUIRED	SF	8.	8.	15.	5.	50.	8.
11.	ØPEN STØRAGE REQUIRED	SF	110.	110.	125.	50.	275.	75.
13.	RUNWAY LØAD FACTØR	**	2.	1.	2.	1.	2.	1.
14.	RUNWAY CØMPØSITIØN FACT.	**	1.	2.	2.	2.	2.	2.
18.	ANNUAL FUEL (THØUS.)	GA	50.	180.	189.	5.	360.	19.
19.	FUEL TYPE 1-JET 2=AGAS	**	2.	1.	2.	2.	2.	2.

* As of 1 January 1970.

6. Aircraft per Crew & Equipment Module— The maximum number of aircraft of each type that can be serviced by one Crew & Equipment/Administrative Module. Source: NAVFAC P-80, Table 21-5, p. 210-9.

7. Aircraft per Base Shop Module— The maximum number of aircraft of each type that can be serviced by one basic shop maintenance module. Source: NAVFAC P-80, p. 210-6.

8. Aircraft per Supplementary Shop Module— The maximum number of aircraft of each type that can be serviced by one supplementary shop maintenance module. Source: NAVFAC P-80, Table 21-3, p. 210-7.

9. Covered Warehouse Space— The number of square feet of ready issue warehouse space allowed per aircraft for each aircraft type. Source: NAVFAC P-80, Table 44-3, pp. 440-16, 440-17.

10. Shed Space Required— The number of square feet of ready use shed space allowed per aircraft for each aircraft type. Source: NAVFAC P-80, Table 44-3, pp. 440-16, 440-17.

11. Open Storage Required— The number of square feet of open improved storage space allowed per aircraft for each aircraft type. Source: NAVFAC P-80, Table 44-3, pp. 440-16, 440-17. (Currently not used in model.)

12. Runway Length Required (Training Aircraft File Only)— The approximate length of a runway required for operations of each aircraft type. Source: NAVFAC P-80, p. 110-4.

13. Runway Load Factor-- One of nine factors developed by ORI 3/ to describe runway thickness required for each aircraft type. Source: See Appendix H.

14. Runway Composition Factor— The code describing the required composition of the runway. 1 specifies a composition of concrete (for jet aircraft); 2 specifies a composition of asphalt (for prop and helo aircraft).

15. Investment Cost (Training Aircraft File Only)— The initial cost per aircraft in thousands of dollars for each aircraft type. Source: See Appendix I for these data.

3/ See Appendix H for exact definition of each factor.

16. O&M Cost per Flight Hour (Training Aircraft File Only)— The cost of consumable spare parts for each aircraft type. Source: See Appendix I for these data.

17. Inventory (Training Aircraft File Only)— The total number of aircraft available to CNATRA for each aircraft type. Source: Facilities, Personnel and Aircraft Summary, pp. 4, 6, 11, 15, 19, 23, 27, 31.

18. Annual Fuel (Thousands)(Tenant and NAS Aircraft Only)— The average number of gallons of fuel consumed per aircraft for each aircraft type. Source: NAVAER OD-100-504, "Programming Guide," U.S. Naval Aeronautical Shore Facilities, March 1958, Table 100-A, p. 100-11.

19. Fuel Type (Tenant and NAS Aircraft Only)—The code describing the type of fuel consumed by each aircraft type. 1 indicates Jet; 2 indicates Avgas; 3 indicates helo fuel.

Aircraft Type Definition

E.5 In order to be able to keep the number of aircraft types manageable so that meaningful comparisons could be made between aircraft requirements and assets, it was found necessary to group similar aircraft into one category on the basis of use. For phase (pilot training) related aircraft, 10 categories were defined for the 10 basic types of aircraft utilized in present pilot training programs. These categories are given in Table E.4 along with the aircraft included within the aircraft type definition. In general, for phase related aircraft, each aircraft type defines only one type of aircraft or a slightly modified version of that type. For tenant and NAS aircraft, the definitions of aircraft type were broadened considerably, and only six types of aircraft were defined. More precise definitions were not required for these aircraft, because no aircraft excess/deficiency comparisons are made, and investment costs are not calculated. The designations of aircraft types as given in Table E.4 are utilized throughout the IFRS effort and specifically in Tables E.1, E.2, and E.3 of this appendix.

TABLE E.4

ALTERNATIVE AIRCRAFT DESIGNATIONS

IFRS Designation	Aircraft Types Included Within Designated Category
Phase Aircraft*	
T34B	T-34
T28C	T-28B, T-28, T-28C
T-2A	T-2A
T2BC	T-2B, T-2B/C
TF9J	TF-9J, AF-9J
TA4J	TA-4J
TS2A	TS-2A
TH1L	TH-1L
TH57	TH-13M
H-34	UH-34
Tenant and NAS Aircraft	
VF	F-11, TF-9J, AF-9J
VT	T-33, T-28, T-34, T-1A, T-29
VR	C-131, C-54, C-117, UC-45J, C-121, RG-45J, C-47H, C-47, UC-47H, C-47H/J, C-45J, TC-117D
VO	U-11
VW	EA-1E
H	UH-2B, UH-34J, UH-34

* Limited to four characters by the computer program.

APPENDIX F

ASSET POSITION DATA FILE

INTRODUCTION

F.1 The purpose of the Asset Position Data File is to provide a complete and current record of the total permanent assets located at each of the eight NASs used in the pilot training program for each of the facilities in the Facilities Requirements Submodel and Runway calculations. This data file is used as an input to the Excess/Deficiency Submodel, which compares the current assets position with facility requirements for each base, thereby identifying the excesses or deficiencies of each facility type for each pilot training alternative. The Asset Position Data File is shown within the context of the overall IFRS effort in the Introduction to this volume.

F.2 The Data File is divided into nine parts, one part for each of the eight NASs under study and one for the phantom base. For each base, the amount of each facility type actually existing is classified as either standard (adequate) condition or substandard (inadequate) condition. The data files can be easily modified as necessary to reflect changes in the fixed assets of a base resulting from new military construction, facility refurbishments, or facility demolition.

DETAILS OF THE DATA FILE

F.3 Complete listings of all data currently stored in the Asset Position Data File for each of the nine NASs being studied are shown in Tables F.1 and F.2. Table F.1 gives data for all facilities of the Facilities Requirements Submodel (except Taxiways and Runway Lighting[1]); Table F.2 provides data utilized in the Runway calculations. The runway section of the data file can both

---

[1] As discussed in Appendix G, these facilities were not included because no net facility requirement is calculated for these facilities.

AD-A043 862 OPERATIONS RESEARCH INC SILVER SPRING MD F/G 5/1
DEVELOPMENT OF A PRELIMINARY AUTOMATED TOTAL SYSTEMS MODEL FOR --ETC(U)
FEB 70 T N KYLE, R D HEILBRON, J D AVILA N00025-67-C-0031
UNCLASSIFIED ORI-TR-583-VOL-2 NL

2 OF 2
AD
A043862

END
DATE
FILMED
9-77
DDC

TABLE F.1

ASSET POSITION DATA FILE

IFRS Category Code	Facility Description	Unit	Naval Air Station Assets: Chase		Corpus Christi		Ellyson		Kingsville		Meridian		Pensacola		Saufley		Whiting		Phantom	
			Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.	Standard	Sub Std.
11320	Aircraft Parking Apron	SY	130,361	0	427,700	0	358,146	0	241,954	0	288,263	0	465,876	0	135,932	0	350,555	0	0	0
–	Aircraft Ready Fuel Storage																			
–	Jet	GA	1,701,000		0		0		3,768,000		2,334,990		2,268,000		15,000		733,840		0	
–	AVGAS	GA	100,000		1,300,000		114,960		600,000		49,980		923,916		150,000		452,330		0	
–	Helo	GA	0		0		0		0		0		0		0		15,000		0	
12540	Distribution Pipeline (Fuel)	MI	0	0	8.55	0	2.3	0	1.97	1.5	1.87	0	17.03	0	0	0	3.86	0	0	0
14140	Aircraft Operations Building and Control Tower	SF	21,858	0	61,573	7,692	1,409	0	16,636	0	12,217	0	20,274	0	12,421	0	5,231	0	0	0
17110	Academic Instruction Building	SF	21,832	0	0	37,661	29,023	0	15,165	0	30,023	0	13,406	0	34,601	0	6,028	29,459	0	0
21110	Aircraft Maintenance Hangars	SF	209,473	0	0	572,210	87,654	0	381,285	0	125,764	0	228,381	0	111,685	0	157,501	0	0	0
21910	Public Works Maintenance Shop	SF	27,370	512	53,237	20,053	4,551	1,071	2,994	24,492	9,080	0	71,028	0	11,713	0	23,315	0	0	0
44210	Total Ready Issue Covered Storage	SF	78,312	19,215	414,794	518,226	22,576	51,968	150,289	0	95,893	14,880	1,168,499	0	31,634	0	27,894	19,220	0	0
55010	Dispensary With/Without Beds	SF	0	15,136	0	21,100	8,345	0	21,838	0	19,562	0	16,605	0	7,471	0		11,204	0	0
61010	Administration Offices	SF	60,563	1,951	77,693	196,794	10,740	0	27,092	0	33,938	0	276,314	0	15,791	0	21,119	5,062	0	0
71110	Family Housing (Officers and Eligible EM)	UN	568	205	1,383	428	460	576	898	209	760	131	1,099	1,379	380	576	921	394	0	0
0	Family Housing (Ineligible EM)	UN	110	108	294	127	127	49	226	35	121	15	105	311	36	105	114	154	0	0
72210	Enlisted Men's Barracks Without Mess	MN	954	451	1,251	195	544	0	820	796	1,148	0	2,910	0	22	603	566	644	0	0
72310	Enlisted Men's Mess Hall	SF	18,500	16,151	0	33,290	9,251	0	28,068	0	19,241	0	17,793	0		12,055		13,721	0	0
72415	Bachelor Officers' Quarters	MN	40	80	76	100	134	0	120	100	275	0	577	0	374	0		246	0	0
74014	Exchange	SF	9,355	0	0	27,329	7,027	0	22,662	0	18,610	0	78,203	0	5,705	0	3,093	13,033	0	0
74063	Enlisted Men's Service Club	SF	12,730	0	0	23,334	2,816	0	7,590	0	7,507	0	15,383	0	2,435	4,870		9,788	0	0
81230	Distribution Line (Electrical)	LF	94,925	0	340,069	0	50,170	0	103,086	0	111,360	0	669,038	0	33,986	0	64,747	0	0	0
84210	Water Distribution Line (Potable)	LF	67,885	0	251,642	0	31,645	0	82,185	0	72,089	0	693,604	0	21,632	0	65,217	0	0	0
85110	Roads	MI	14.72	0	44.65	0	5.8	0	34.06	0	14.16	0	58.91	0	6.29	0	27.77	0	0	0
85210	Parking Area	SY	89,381	0	369,800	0	25,709	0	148,978	0	76,290	0	311,850	0	22,134	0	104,310	0	0	0

TABLE F.2

ASSET POSITION DATA FILE—RUNWAYS

Runway Number	Description of Data	Naval Air Station								
		Chase	Corpus Christi	Ellyson	Kingsville	Meridian	Pensacola	Saufley	Whiting	Phantom
1	Fraction of Time Runway is Usable	.839	.839	.900	,925	.900	.900	.100	.900	0
	Length of Runway, ft.	8,000	8,000	3,125	8,000	8,000	8,000	5,200	6,000	0
	Load Bearing Factor *	9	9	1	9	9	9	9	1	0
	Composition Factor **	1	1	2	1	1	1	1	2	0
2	Fraction of Time Runway is Usable	.839	.839	.900	.925	.900	.100	.900	.900	0
	Length of Runway, ft.	8,000	5,000	3,025	8,000	8,000	6,137	6,035	6,000	0
	Load Bearing Factor *	9	2	1	9	9	9	1	1	0
	Composition Factor **	1	2	2	1	1	1	2	2	0
3	Fraction of Time Runway is Usable	.086	.820	.900	.075	.745	0	.100	.100	0
	Length of Runway, ft.	6,000	5,000	3,350	8,000	6,400	0	5,296	6,000	0
	Load Bearing Factor *	9	2	1	9	9	0	1	1	0
	Composition Factor **	1	2	2	1	1	0	2	2	0
4	Fraction of Time Runway is Usable	0	.622	.100	0	0	0	.900	.100	0
	Length of Runway, ft.	0	5,000	3,185	0	0	0	5,356	6,000	0
	Load Bearing Factor *	0	2	1	0	0	0	1	1	0
	Composition Factor **	0	2	2	0	0	0	2	2	0
5	Fraction of Time Runway is Usable	0	.641	0	0	0	0	0	0	0
	Length of Runway, ft.	0	5,000	0	0	0	0	0	0	0
	Load Bearing Factor *	0	2	0	0	0	0	0	0	0
	Composition Factor **	0	2	0	0	0	0	0	0	0

* See Appendix H for the definition of load bearing factors .

** 1 means a composition of concrete or concrete ends (i.e., usable by jet aircraft); 2 means bituminous (usable by propeller and helo aircraft).

F.4 The data shown in Table F.1 are the data for each facility as defined by the Facilities Requirements Submodel. As previously indicated, the definitions of some facilities differ slightly from the definitions of the category codes used by the Navy. This difference posed somewhat of a problem when compiling the data, since it was necessary to include in the data file only the data covered by the definition of the IFRS model. An additional complication arose because the individual NASs, when compiling their Real Property Inventories, Asset Position Forms, and Basic Facility Requirements Listings (BRFLs), did not necessarily apply Navy definitions consistently. Furthermore, different bases often defined data differently. These data discrepancies necessitated making some judgments in compiling the data. In making these decisions, the definitions of the facilities made in the IFRS effort were applied, and data were judged on the basis of whether they were accurately described by the IFRS definitions.

F.5 Table F.1 and F.2 provide data for each major base including all activities and non-contiguous areas listed under its command in NAVFAC P-164. In addition, the PWC complexes for Pensacola, Saufley, and Ellyson were included. However, outlying fields and the Auxiliary Landing Field of Orange Grove were not included. The data base does not include the following runway systems because either they have been abandoned or they are not or cannot be used concurrently with listed runways due to excessive congestion and interference with present runway flight patterns:

a. Entire South Field of NAS Kingsville

b. Runways 9/27 and 18/36 of the North Field and 9/27 and 18/36 of the South Field of NAS Whiting

c. Runways 13R/31L, 18R/36L, 9L/27R, and 4L/22R of NAS Ellyson

d. Chevalier Field at NAS Pensacola.

All other runways are included in the data.

F.6 Data for Family Housing (both eligible and ineligible) were obtained from DD Form 1377 and include all military and privately owned and all rented housing utilized by personnel at that base. In the case of the Pensacola area, DD Form 1377 gives housing figures to cover, in total, the three bases of NAS Pensacola, NAS Saufley, and NAS Ellyson. These housing figures were allocated to the three bases as follows: The number of personnel eligible for family housing was totaled for the three bases. The fraction of total eligible personnel, which individual base personnel represented, was then derived and this fraction was multiplied by the total available housing (in both standard and substandard condition categories) to obtain an estimate of housing available at each base. The same procedure was followed for ineligible family housing. These figures are shown in the present Asset Position Data File, Table F.1.

DATA SOURCES

F.7 The sources of the data listed in Table F.1 are:

- OPNAV Form 11000-2 "Evaluation of Existing Shore Facility Assets," dated as follows:

Base	Date Prepared
Chase	6 December 1967
Corpus Christi	7 August 1968
Ellyson	10 September 1965
Kingsville	16 March 1967
Meridian	6 December 1968
Pensacola	17 March 1965
Saufley	31 October 1967
Whiting	8 January 1968

- NAVFAC P-164 "Detailed Inventory of Naval Shore Facilities," 30 June 1968
- DD Form 1377, 31 January 1968
- Military Construction Program, Navy FY69 and FY70 Program Cost Estimates
- Military Construction Authorization Appropriation FY70.

The primary source of data for all facilities except Family Housing was OPNAV Form 11000-2. However, when compiling the data, data from both OPNAV 11000-2 and NAVFAC P-164 were carefully compared to ensure that data in these two references were both correctly categorized and consistent with each other. In numerous cases, discrepancies did exist between the two sources, either in amount or by category, or due to definition problems. In such cases, the discrepancies were carefully reviewed and resolved by using the data that appeared most correct. The data compiled from OPNAV 11000-2, NAVFAC P-164, and DD 1377 were then augmented, as appropriate, by facilities listed to be built in the Military Construction Programs of FY69 and FY70. Thus, the final data base listed in Tables F.1 and F.2 should correctly reflect the current asset position at each base.

F.8 Although the data given in Table F.1 and F.2 are the most accurate data available at the present time, they must be periodically updated to remain accurate. This updating is accomplished by changing the data in the file to reflect:

- New Military Construction
- Revised Family Housing Data
- Demolition of Present Facilities.

Therefore, the data file should be reviewed periodically as new or revised data become available and adjusted accordingly.

FACILITY CONDITION

F.9 The facilities listed in Tables F.1 and F.2 are classified as standard or substandard condition. Since these two designations are used in OPNAV 11000-2 to designate facility condition, it was decided that these definitions should be kept in the IFRS Model to provide management with a greater flexibility in evaluating excesses and deficiencies.

F.10 However, the condition coding in NAVFAC P-164 is somewhat more detailed than that in OPNAV 11000-2 and lists the following five facility condition codes:

- U—Usable without change or major repairs
- T—Being used, but complete replacement required; condition does not warrant repair or improvement
- R—Usable, but major repairs and/or improvements are required to meet structural/space criteria
- C—Unsuitable for present use, but is structurally sound and can be converted for other use
- N—Not usable, a structure which has deteriorated beyond economical restoration or constitutes a danger to health or safety of personnel or equipment.

Whenever it was necessary to use NAVFAC P-164 data (because of discrepancies with OPNAV 11000-2 or other data problems), the following rules were used: U designated a standard condition facility; T, R, and C designated substandard condition facilities; and facilities labeled N were not included within the data base.

ANNUAL ASSET POSITION UPDATE

F.11 In addition to the routine updating of the file, the Asset Position File can be temporarily modified to reflect postulated future Military Construction Programs. In this case, the amount of the facility deficit to be built in the given year is automatically entered into the program and this postulated construction is carried throughout the program (through future years, etc.) as having been built in that year, with the Asset Position File modified to reflect this modification. As long as that program is being run, this postulated construction is made a part of the Asset Position File. However, this postulated construction <u>is not</u> entered permanently in the data file. Therefore, on starting a new program run, the original Asset Position Data File (as described in paragraphs F.1 to F.10) is used.

APPENDIX G

EXCESS/DEFICIENCY SUBMODEL

INTRODUCTION

G.1 The purpose of the Excess/Deficiency Submodel is to compare the requirements for facilities at a base with the availability of facilities at that base and compute the net excess or deficiency of facilities. The inputs to the Submodel are from the Facilities Requirements Submodel, which gives the required amount for each facility, and the Asset Position Data File, which gives the available amount of each facility. The output of the Excess/Deficiency Submodel is the net requirement for each facility, listed as either an excess (indicating more assets than requirements) or a deficiency (indicating more requirements than assets). The Submodel is shown within the context of the overall IFRS effort in the Introduction to this volume of appendices.

DETAILS OF THE SUBMODEL

G.2 To compute net requirements (excesses or deficiencies) of facilities, three distinctly different types of calculations were used. The first type is a simple subtraction in which base assets are subtracted from gross (total base) requirements to obtain a net requirement. The second type of calculation is the interactive kind used to derive net runway requirements, in which the net requirements are derived in several stages, including a detailed excess/deficiency comparison during the requirement calculation. The third type of calculation gives the net requirements only, with no excess/deficiency comparison.

G.3 The simple subtraction type of calculation is of the form

$$NR_{ik} = GR_{ik} - AP_{ik}^{s} \qquad (G.1)$$

or

$$NR_{ik} = GR_{ik} - (AP_{ik}^{s} + AP_{ik}^{ss}) \qquad (G.2)$$

where NR_{ik} = net requirement for facility type k at base i

GR_{ik} = gross (total) requirement for facility type k at base i

AP^{s}_{ik} = assets of standard condition of facility type k at base i

AP^{ss}_{ik} = assets of substandard condition of facility type k at base i.

Equation (G.1) simply states that the net requirement for facilities is the gross requirement minus the standard assets available. Equation (G.2) is used to calculate net facility requirements when both standard and substandard assets are assumed to be used. Either Equation (G.1) or (G.2) is used to calculate the net requirements for all facilities in the Facilities Requirements Submodel, except Taxiways, Runway Lighting, and Ready Fuel Storage.

G.4 The interactive type calculation is used to calculate Ready Fuel Storage and runway deficiencies. In the case of Ready Fuel Storage, a subtraction of the type indicated in Equation (G.1) is carried out for each of three fuel types. The requirement for fuel tanks is then calculated by comparing net requirements in gallons of fuel to be stored with tank capacities. The result of the comparison provides the number of tanks required, specified by tank capacity. This calculation is repeated, as necessary, for each of the three fuel types. The Runway Methodology (described in more detail in Appendix H) uses a similar type of comparison in which the requirement is expressed not only in quantity (number of runways) but also by type (length, load capacity, etc.). In addition, assets must be matched to requirements by amount and type.

G.5 The final type of calculation of net requirements is not a comparison but is a straightforward calculation of net deficiencies (if any). This type of calculation is used in IFRS for Taxiways and Runway lighting, because these two facilities are assumed to be built only if a runway is to be built. The derivation of net requirements for these facilities is given in the Annex to Appendix D.

G.6 The output of the Excess/Deficiency Submodel can be printed out if desired along with the facility requirements and Asset Position File. A sample output is provided subsequently. Deficient facility outputs are used as inputs to the Total Systems Cost Submodel, which calculates the investment required to build these deficient facilities.

SAMPLE OUTPUTS

G.7 Tables G.1 and G.2 show sample outputs of the Excess/Deficiency Submodel for the NAS at Meridian and the base loading provided on page C-11 of Appendix C. Table G.1 provides the comparison in which substandard facilities are not included as acceptable assets. Table G.2 gives the same comparison with substandard facilities included as assets. The 19 facilities for which the simple subtraction comparison is used are printed out in one block with

TABLE G.1

SAMPLE PRINTOUT OF FACILITIES REQUIREMENTS AND EXCESS/DEFICIENCY SUBMODELS USING STANDARD FACILITIES ONLY

NAS--MERI
DETAILED EXCESS-DEFICIENCY (Y,N)?Y

		REQUIRED		AVAILABLE		POSITION	
CODE	DESCRIPTION	AMOUNT	UNIT	STAND.	SUB-STAND.	EXCESS	DEFICIENT
1320	A/C PKNG APN	221667.	SY	0.	0.	0.	0.
1320	PER TAXIWAY	128333.	SY	0.	0.	0.	0.
11320	TOT PKNG APN	350000.	SY	288263.	0.	0.	61737.
12540	DIST PIPELIN	3.	MI	2.	0.	0.	1.
14140	A/C OP BLDG	16956.	SF	12217.	0.	0.	4739.
17110	ACADEMC BLDG	5758.	SF	30023.	0.	24265.	0.
21110	MAINT HANGAR	222732.	SF	125764.	0.	0.	96968.
21910	PW MAINT SHP	9364.	SF	9080.	0.	0.	284.
4210	GEN WAREHOUS	125000.	SF	0.	0.	0.	0.
4210	SHED SPACE	8074.	SF	0.	0.	0.	0.
44210	TOT WAREHSE	133074.	SF	95893.	14880.	0.	37181.
55010	DISPENSARY	17037.	SF	19562.	0.	2525.	0.
61010	ADMIN OFFICE	51447.	SF	33938.	0.	0.	17509.
71110	FAM HOUSING	1319.	UN	760.	131.	0.	559.
0	INELIG HOUSE	208.	UN	121.	15.	0.	87.
72210	EM BARRACKS	937.	MN	1148.	0.	211.	0.
72310	EM MESS HALL	11941.	SF	19241.	0.	7300.	0.
72415	BOQ	325.	MN	275.	0.	0.	50.
74014	EXCHANGE	13050.	SF	18610.	0.	5560.	0.
74063	SERVICE CLUB	12685.	SF	7507.	0.	0.	5178.
81230	ELEC DIST LN	115876.	LF	111340.	0.	0.	4536.
84210	WATER DIS LN	53463.	LF	72089.	0.	18626.	0.
85110	ROADS	20.	MI	14.	0.	0.	5.
85210	PARKING AREA	83729.	SY	76290.	0.	0.	7439.

TAXIWAYS & RUNWAY LIGHTING
NO DEFICIENCY
READY FUEL STORAGE
REQUIRED: (THOUSANDS OF GALS)
JET 1374.7
AVGAS 12.1
AVAILABLE:
JET 2335.0
AVGAS 50.0
HELO 0.
NO DEFICIENCY

TABLE G.2

SAMPLE PRINTOUT OF FACILITIES REQUIREMENTS AND EXCESS/DEFICIENCY SUBMODELS ACCEPTING SUBSTANDARD FACILITIES

NAS--MERI
DETAILED EXCESS-DEFICIENCY (Y,N)?Y

		REQUIRED		AVAILABLE		POSITION	
CODE	DESCRIPTION	AMOUNT	UNIT	STAND.	SUB-STAND.	EXCESS	DEFICIENT
1320	A/C PKNG APN	221667.	SY	0.	0.	0.	0.
1320	PER TAXIWAY	128333.	SY	0.	0.	0.	0.
11320	TOT PKNG APN	350000.	SY	288263.	0.	0.	61737.
12540	DIST PIPELIN	3.	MI	2.	0.	0.	1.
14140	A/C OP BLDG	16956.	SF	12217.	0.	0.	4739.
17110	ACADEMC BLDG	5758.	SF	30023.	0.	24265.	0.
21110	MAINT HANGAR	222732.	SF	125764.	0.	0.	96968.
21910	PW MAINT SHP	9364.	SF	9080.	0.	0.	284.
4210	GEN WAREHOUS	125000.	SF	0.	0.	0.	0.
4210	SHED SPACE	8074.	SF	0.	0.	0.	0.
44210	TOT WAREHSE	133074.	SF	95893.	14880.	0.	22301.
55010	DISPENSARY	17037.	SF	19562.	0.	2525.	0.
61010	ADMIN OFFICE	51447.	SF	33938.	0.	0.	17509.
71110	FAM HOUSING	1319.	UN	760.	131.	0.	428.
0	INELIG HOUSE	208.	UN	121.	15.	0.	72.
72210	EM BARRACKS	937.	MN	1148.	0.	211.	0.
72310	EM MESS HALL	11941.	SF	19241.	0.	7300.	0.
72415	BOQ	325.	MN	275.	0.	0.	50.
74014	EXCHANGE	13050.	SF	18610.	0.	5560.	0.
74063	SERVICE CLUB	12685.	SF	7507.	0.	0.	5178.
81230	ELEC DIST LN	115876.	LF	111340.	0.	0.	4536.
84210	WATER DIS LN	53463.	LF	72089.	0.	18626.	0.
85110	ROADS	20.	MI	14.	0.	0.	5.
85210	PARKING AREA	83729.	SY	76290.	0.	0.	7439.

TAXIWAYS & RUNWAY LIGHTING
NO DEFICIENCY
READY FUEL STORAGE
REQUIRED: (THOUSANDS OF GALS)
JET 1374.7
AVGAS 12.1
AVAILABLE:
JET 2335.0
AVGAS 50.0
HELO 0.
NO DEFICIENCY

either the excess or deficiency of the facility noted. Because no asset position data are available for subcategories 1320 and 4210, an excess/deficiency comparison is not made although a gross requirement is calculated. The Ready Fuel Storage, Taxiway, and Runway Lighting requirements are printed out with only deficiencies (if any) noted. Runway requirements are, of course, computed and printed out separately (see Appendix H).

APPENDIX H

RUNWAY METHODOLOGY

INTRODUCTION

H.1 The purpose of this appendix is to discuss the methodology developed to calculate runway, outlying field (OLF), and air-to-ground target area requirements; runway deficiencies; and airfield pavement (i.e., runways, taxiways, and parking aprons) investment costs. A runway submodel does not appear as a separate entity in the flow chart of Figure A.1, since these calculations are completed in several of the IFRS submodels. However, due to the unique features of runways, the discussion of these calculations is more useful if contained in one comprehensive section rather than scattered throughout Volume II.

H.2 The runway, OLF, and air-to-ground target area requirements are calculated in the LSR Generator for each phase of training. The phase specific requirements are then converted to base specific requirements in the Base Loading Submodel. Next, for each base, the runway requirements are compared to the existing runways available, to calculate runway deficiencies. Finally, the cost of making up all deficiencies, by upgrading (i.e., extending length or increasing thickness) an existing runway and/or building new runways, is estimated.

H.3 The methodologies applied to the other facilities could not be directly applied to runways due to the unique features of runways. In the IFRS model runways are defined by five characteristics:

- Amount Available—The amount of time a runway can be used as a primary runway, taking local wind conditions into account (e.g., if the local wind conditions are such that 20 percent of the

time a runway cannot be used for a primary runway, the amount available is .80 or 1.00 - .20).[1/]

- Amount Required—The number of "pure" runways required by aircraft type, without a wind correction (this amount can be directly compared to the amount available).

- Length—The length, in feet, of a runway, which is a function of the type of aircraft utilizing the runway.

- Thickness—The number of inches of surface and base material required, which is a function of aircraft type. Each aircraft type has a thickness factor (ranging from 1 to 9) associated with it, as developed in this appendix.

- Composition—The type of surface, either rigid (portland cement) or flexible (bituminous), which is also a function of aircraft type. The model uses this factor for costing new runways.

RUNWAY REQUIREMENTS

H.4 A tabulation of the data supplied by NATRACOM and used in the runway methodology is contained in Table H.1. These data are currently utilized by the automated IFRS model.

H.5 The methodology for estimating runway, OLF, and air-to-ground target area requirements by aircraft type for each phase of pilot training was developed in Phase I of the IFRS and is documented in the Phase I Final Report.[2/] In the automation of this methodology minor modifications were made to extend the methodology and improve the computational sequence. The methodological changes include a revised technique for estimating daylight hours and runway utilization, and a runway optimization procedure to maximize daily runway sortie capacity.

H.6 Three steps are required to estimate the number of runways necessary for each pilot training phase. First the average number of daily daylight hours a runway may be utilized is established. Next, the runway's maximum daily sortie capacity consistent with airspace limitation is computed. Finally, the daily student sortie requirements are generated. The runway requirements are estimated as the ratio of daily sortie requirements to runway sortie capacity.

1/ Based on wind rose data for each naval air station.

2/ Integrated Facilities Requirements Study, Phase I—Development of the Two Model System, ORI TR 520, 5 December 1968.

TABLE H.1

RUNWAY DATA*

Name	Primary	Basic Jet-A	Basic Jet-B	B-Jet G/CQ	Advanced Jet-TF	Advanced Jet-TA	Basic Prop	B-Prop CQ	Advanced Prop	Pre Helo	Helo Primary	Helo Advanced
Aircraft	T34B	T-2A	T2BC	T2BC	TF9J	TA4J	T28C	T28C	TS2A	T28C	TH57	THIL
Runway down time (%)	15	15	15	15	15	15	15	15	15	15	15	15
OLF down time (%)	50	50	50	50	50	50	50	50	50	50	50	50
No. of sorties	27	48	38	29	105	105	75	16	39	14	22	30
Sortie length	1.30	1.43	1.47	1.11	1.36	1.36	1.54	1.03	2.78	1.78	1.19	1.79
Launch time	0.0076	0.0083	0.0083	0.0076	0.0298	0.0298	0.0048	0.0042	0.0319	0.0128	0.0270	0.0210
Recovery time	0.0122	0.0158	0.0158	0.0144	0.0250	0.0250	0.0120	0.0256	0.0233	0.0156	0.0180	0.0140
Maximum No. aircraft which can be simultaneously aloft	109	56	56	38	413	413	278	1000	204	1000	20	40
Touch and go operations	9	16	13	10	33	33	24	6	13	5	8	10
Touch and go cycle time	0.0146	0.0190	0.0190	0.0173	0.0300	0.0300	0.0146	0.0307	0.0279	0.0187	0.0216	0.0168
% of TG on main runway	5	5	5	5	5	5	5	5	5	5	5	5
Day hours – Jan (HD_i)	9.380	9.250	9.250	9.380	9.500	9.500	9.380	9.380	9.500	9.380	9.380	9.380
Feb	10.080	10.020	10.020	10.080	10.200	10.200	10.080	10.080	10.200	10.080	10.080	10.080
Mar	10.970	10.930	10.930	10.970	10.980	10.980	10.970	10.970	10.980	10.970	10.970	10.970
Apr	11.850	11.920	11.920	11.850	11.850	11.850	11.850	11.850	11.850	11.850	11.850	11.850
May	12.680	12.820	12.280	12.680	12.530	12.530	12.680	12.680	12.530	12.680	12.680	12.680
Jun	13.120	13.280	13.280	13.120	12.650	12.650	13.120	13.120	12.850	13.120	13.120	13.120
Jul	12.920	13.050	13.050	12.920	12.770	12.770	12.920	12.920	12.770	12.920	12.920	12.920
Aug	12.250	12.350	12.350	12.250	12.150	12.150	12.250	12.250	12.150	12.250	12.250	12.250
Sep	11.380	11.450	11.350	11.380	11.380	11.380	11.380	11.380	11.380	11.380	11.380	11.380
Oct	10.500	10.430	10.430	10.500	10.600	10 600	10.500	10.500	10.600	10.500	10.500	10.500
Nov	9.620	9.480	9.480	9.620	9.780	9.780	9.620	9.620	9.780	9.620	9.620	9.620
Dec	9.230	9.100	9.100	9.230	9.420	9.420	9.230	9.230	9.420	9.230	9.230	9.230
% Weather – Jan (WX)	63	59	60	68	68	68	63	76	67	71	70	75
Feb	65	63	65	67	79	79	65	78	76	77	71	75
Mar	69	78	80	69	81	81	71	82	85	80	73	77
Apr	75	82	84	74	81	81	76	88	83	87	79	83
May	84	88	90	89	86	86	82	88	89	91	87	91
Jun	83	85	87	83	89	89	77	89	94	86	87	91
Jul	87	90	92	89	95	95	81	89	97	92	89	93
Aug	83	91	94	85	95	95	80	90	97	89	90	94
Sep	86	81	83	83	91	91	76	88	95	89	90	92
Oct	88	86	89	89	90	90	86	95	94	91	91	95
Nov	75	75	76	71	87	87	73	88	87	85	81	86
Dec	68	77	79	81	66	66	66	81	67	80	72	76

* Supplied by NATRACOM.

Runway Utilization

H.7 The number of daily hours a runway may be utilized varies due to seasonal fluctuations in the weather and the prevailing daylight hours. To develop the average daily number of daylight hours (DH) a runway may be utilized, Equation (H.1) is employed:

$$DH = (1.0 - DT) \sum_{i=1}^{12} (HD_i - LS)(WX_i)\left(\frac{DPM_i}{AFD}\right) \qquad (H.1)$$

where

DT = average percentage of time that a runway may not be utilized for the launch or recovery of pilot training sorties; e.g., the runway is down due to missed approaches, emergency conditions, other non-pilot training utilization, etc.

HD_i = average daily number of daylight hours in month i; i.e., the average elapsed time from $\frac{1}{2}$ hour after sunrise to $\frac{1}{2}$ hour before sunset

LS = length of time of an average sortie

WX_i = percent of time in the i^{th} month that weather will permit scheduled sorties to be flown

DPM_i = days in month i that are to be scheduled for flight training

AFD = annual days which are scheduled for flight training ($AFD = \sum_{i=1}^{12} DPM_i$).

H.8 The first term, 1.0 - DT, of Equation (H.1) reduces the average daylight hours to account for the percentage of time a runway is not available for pilot training sorties. For example, when a runway is utilized for other non-pilot training launches and recoveries, it can be considered to be "down." Consequently, the scheduled sorties for that time interval are delayed or rescheduled.

H.9 The term, HD_i - LS, in Equation (H.1), reduces the average number of daily hours by the length of the average sortie. Since all sorties must be completed in daylight hours,[3] the last LS hours of the day may not be used for the launching of sorties (if a sortie were launched in this period of time, it could not be completed during the daylight hours).

---

[3] Only daylight sorties are considered. It is assumed that ample time exists to complete night sorties as they constitute only a minor percentage of all sorties.

H.10 The fourth bracketed portion of Equation (H.1), DPM_i/AFD, weights the daily flight hours by the number of scheduled days per month. For example, should a particular month have proportionally fewer daylight hours than another month, and also have a fewer number of scheduled fly days, the weighting factor would reduce the impact of this month on average daily hours, (DH), a runway can be used. The weather factor, WX_i, adjusts the average daily hours to reflect climatological conditions.

H.11 DH, then, contains the average number of daylight hours a runway may be utilized for pilot training sorties. It should be noted that DH assumes perfect wind conditions, i.e., when wind exists it will not detain any sortie. Wind rose data are included in determining runway assets, as they are unique to a particular runway, viz., a main and a cross wind runway may be physically identical but have different availabilities due to wind conditions.

Daily Sortie Capacity

H.12 To determine the daily sortie capacity of a runway, the runway operating procedures must be established. Two different operating procedures may be utilized for the launch and recovery of aircraft on a runway:

a. Cycle launches occur when the launch of a sortie is immediately followed by the recovery of an aircraft which has just completed its sortie. (Note: an initialization period is required at the onset of a day prior to the time launches and recoveries can be intermittently spaced in time.)

b. Batch launches occur when aircraft are continuously launched until the first aircraft returns from its sortie. All aircraft are then recovered prior to the launch of the next "batch" of aircraft.

Each of these operating procedures provides different daily sortie capacities, depending on the time required to launch and recover an aircraft and the number of aircraft which can be simultaneously aloft. The IFRS model computes all possible daily sortie capacities, viz., both runway operating procedures with and without airspace constraints. The daily sortie capacity developed is the maximum sortie capacity permissible with airspace restrictions. The following paragraphs develop the four possible daily sortie capacities.

H.13 Cycle launches—airspace not constrained. For unconstrained cycle launch operations, a launch is immediately followed by an aircraft recovery. If TT is the time required to launch an aircraft, and LT is the recovery time, an aircraft will be launched every LC hours, i.e.,

$$LC = TT + LT. \tag{H.2}$$

Since DH hours exist daily for the launch and recovery of pilot training aircraft, Equation (H.3) develops the maximum number of sorties, SMAX, which can be flown utilizing a cycle launch operating procedure:

$$SMAX = \frac{DH}{LC} \quad . \tag{H.3}$$

It should be noted that the flight time of the last sortie flown each day was removed from DH in Equation (H.1). Consequently DH represents the daily hours a launch-recovery may occur. Using this operational procedure, aircraft are launched every LC hours until the first aircraft returns. Then launches and recoveries are interspersed until the end of the day (after DH hours have elapsed), when aircraft are only recovered.

H.14 Cycle Launches—Airspace Constraining. Airspace limitations will reduce the number of daily sorties flown when it becomes saturated prior to the departure of the last scheduled sortie. When the cycle launch is utilized, aircraft are launched for sortie length hours, LS, prior to recovery. Thus every LS hours, the aircraft which are aloft are totally replenished. Since it is assumed that airspace is constraining, airspace will become saturated prior to LS hours, or Inequality (H.4) must hold:

$$AS < \frac{LS}{LC} \tag{H.4}$$

where AS = maximum number of aircraft which can simultaneously remain aloft without violating the airspace.

H.15 Since airspace is assumed to be an operational constraint, only AS aircraft may be launched every LS hours. Consequently the maximum number of sorties which can be flown daily is:

$$SMAX = MINIMUM\left\{\frac{HD \cdot AS}{SL} \, , \, I \le \left(\frac{DH - LS}{LS}\right) AS + AS\right\} \quad . \tag{H.5}$$

The two computations provided in Equation (H.5) insure that the last daily cycle does not violate airspace limitations. Thus if a non-integer number of complete daily cycles (the number of times all aloft aircraft are replenished) occurs, the last, partial cycle must not violate airspace.

H.16 Batch Launches—Airspace Not Constraining. When sorties are launched and recovered in batches, the runway is initially used solely to launch aircraft. When the first aircraft returns from its sortie, the runway is used solely to recover aircraft. This process is continued throughout the day.

H.17 With batch launches, an aircraft is launched or recovered every BL hours, where

BL = maximum (of either launch or recovery time).

BL must be the greater of launch and recovery time to insure that no sortie will exceed LS duration.[4] Launches can occur until the first aircraft returns from its sortie (LS hours). The number of aircraft which can be launched, AL, in this time period, is developed by Equation (H.6).

$$AL = \frac{LS}{BL} \quad . \tag{H.6}$$

Equation (H.6) states that the total number of aircraft which can be launched in LS hours is that time divided by the time required to launch a single aircraft, BL. Since LS hours are also required to recover the aircraft, AL is the number of sorties which can be flown each 2LS hours.

H.18 When all aircraft have been recovered, the process continues by launching the next batch of sorties. The number of complete batches which can be launched daily, CB, is developed in Equation (H.7):

$$CB = I \leq \frac{DH + LS}{2LS} \quad . \tag{H.7}$$

Equation (H.7) states that CB, the number of complete batches which can be launched daily, is the largest integer less than the ratio of total time to time per batch.

H.19 Since the daylight hours may permit the launch of an incomplete batch, the number of aircraft launched in this batch, EL, must be computed:

$$EL = \frac{DH - 2 \cdot CB \cdot LS}{BL} \quad . \tag{H.8}$$

The bracketed portion of Equation (H.8) computes the time remaining in the day after the last complete batch has been recovered.

H.20 The daily sortie capacity is the product of the number of sorties which can be launched in each complete batch and the number of complete batches per day, plus the number of sorties which are launched in the last batch. Equation (H.9) develops the maximum daily sortie capacity when batch launches are utilized.

$$SMAX = (AL)(CB) + EL \quad . \tag{H.9}$$

4/ For clarity assume launch time is less than recovery time and aircraft are launched at launch time intervals. When the first aircraft returns from its sortie, the second aircraft will be following launch time hours behind. Since the first aircraft will require recovery time hours to land (more time than launch time) the second aircraft will wait recovery time-launch time extra hours. Consequently the sortie time of the second aircraft will be increased. This violates the assumption that an aircraft will fly a sortie of duration LS.

H.21 Batch Launches—Airspace Constraining. Airspace constrains the batch launching process when the maximum number of aircraft which can simultaneously remain aloft, AS, is less than the number of aircraft that can be launched in each batch. Consequently, the batch size, AL, must be reduced to the airspace saturation factor, AS, so airspace will not be violated:

$$AL = AS \; . \tag{H.10}$$

H.22 With a smaller batch size, the total elapsed time required to launch and recover aircraft will decrease. This could result in a greater number of complete launch and recovery cycles which can occur daily, CB. Equation (H.11) develops this calculation:

$$CB = I \le \frac{DH + LS}{LS + AS \cdot BL} \; . \tag{H.11}$$

Since AS · BL hours of launch time exist prior to airspace saturation, a total launch recovery cycle occurs every LS + AS · BL hours. Note Equation (H.11) is similar to Equation (H.7) except a smaller batch size is utilized.

H.23 Since the daylight hours may permit the launch and recovery of an incomplete batch at the end of the day, Equation (H.12) computes the number of sorties which can be flown in the last batch:

$$EL = \text{MINIMUM} \left\{AS, \; (DH - CB \cdot (LS + AS \cdot BL)\right\} \; . \tag{H.12}$$

The computation in Equation (H.12) parallels that of Equation (H.8) except a check must be made to insure airspace will not be exceeded.

H.24 The daily sortie capacity is computed by Equation H.13:

$$SMAX = (AS)(CB) + EL \; . \tag{H.13}$$

Daily Sortie Requirements

H.25 The average number of sorties which must be flown daily, SREQ, is developed in Equation (H.14).

$$SREQ = \frac{SO \cdot SPS}{AFD} \tag{H.14}$$

where SO = annual phase PTR

SPS = average number of sorties which will be flown by each successful student. (Note that overhead sorties due to student attrites, incomplete sorties, etc. are included in SPS.)

Weather is not included in the computation of the average number of daily sorties flown, as it has been accounted for in the computation of average daily daylight hours.

Summary

H.26 The pure runway requirements, RUN, are developed as the ratio of average daily sorties required, SREQ, to daily runway sortie capacity SMAX:

$$RUN = \frac{SREQ}{SMAX} \; . \qquad (H.15)$$

The daily runway capacity is selected as the maximum of equations (H.3), (H.5), (H.9), and (H.13), consistent with airspace limitations. For example, if airspace constrains batch launch operations and cycle launch operations, SMAX is selected as the maximum of Equations (H.3) and (H.13.)

H.27 The above discussion provides the required computations for generating runway requirements based on static launch and recovery times, sortie length, etc. Should several aircraft exist for a phase of pilot training, all computations would be repeated for the different aircraft types. The total runway requirements would then be the aggregate of the individual aircraft runway requirements.

IFRS OLF METHODOLOGY

H.28 Two steps are required to determine the number of outlying fields (OLFs) required for each phase of training. First the annual capacity of an OLF is computed utilizing the following data: weather, daylight hours, runway down time, transit time, and "touch and go" cycle time. Next the annual number of touch and go operations which must be supported by OLFs is developed. When these computations have been completed, the number of OLFs required for each training phase is developed as the ratio of required touch and go operations to the number of operations one OLF can support.

Annual OLF Capacity

H.29 The OLF capacity is computed by first determining the average number of hours per day, HPD, an OLF may be used for touch and go operations. This is established by Equation (H.16):

$$HPD = \sum_{i=1}^{12} (HD_i - 2TT)\left(\frac{DPM_i}{AFD}\right)(WX_i) \qquad (H.16)$$

where HD_i = average number of daylight hours (the time from one half hour after sunrise to one half hour prior to sunset) in the i^{th} month

TT = average transit flight time required to fly an aircraft from the naval air station to the OLF; assumed to be one half the sortie length

DPM_i = scheduled number of fly days in the i^{th} month

AFD = scheduled number of fly days for the year; note that

$$AFD = \sum_{i=1}^{12} DPM_i$$

WX_i = the percent of time in the i^{th} month that weather will permit scheduled sorties to be flown

H.30 The first bracketed portion of Equation (H.16) reduces daylight flying hours by the transit time to and from the OLF. This is required to insure that all OLF operations will be conducted during normal flying hours. The second bracketed portion of the equation, DPM_i/AFD, weights the daily flight hours by the number of scheduled days per month. For example, should one month have proportionally fewer daylight hours than another month, and also have a fewer number of scheduled fly days, the weighting factor would reduce the impact of this month on average daily hours, HPD, an OLF can be used. The weather factor, WX_i, adjusts the average daily hours to reflect climatological conditions.

H.31 The average daily hours an OLF can be used, HPD, is now based on perfect aircraft operational conditions. To achieve a more realistic estimate, HPD must be reduced to reflect missed approaches, nonavailability of support equipment, and normal runway downtime. Note that should the runway at the Naval Air Station be down for some reason or in use for non- touch and go sorties, an impact will arise on OLF utilization. Equation (H.17) develops the effective average daily hours, EHPD, an OLF may be used:

$$EHPD = HPD\,(1.0 - DTO) \qquad (H.17)$$

where DTO = percent of time an OLF is not being used for touch and go operations.

H.32 The daily capacity of an OLF can be computed by dividing the time required for a touch and go operation into the average number of effective daylight hours an OLF may be used. The annual capacity COLF is computed by multiplying daily capacity by the scheduled number of annual fly days. Equation (H.18) performs the latter computation:

$$COLF = (AFD)\left(\frac{EHPD}{TAGT}\right) \qquad (H.18)$$

where TAGT = average time required for a touch and go operation.

Required OLF Operations

H.33 The required number of touch and go operations for each training phase, TAG, is computed in Equation (H.19). The first two factors develop the total

number of touch and go operations which must be performed annually; this value is then decreased by the third factor to reflect the operations which will be conducted on the Naval Air Station's runway:

$$TAG = (SO)(ATAG)(POLF) \tag{H.19}$$

where SO = number of students who will successfully complete the training phase

ATAG = average number of touch and go operations for a successfully trained student (note that ATAG includes an overhead factor to account for students who attrite before completing the training phase)

POLF = percent of touch and go operations which will be conducted at an OLF (i.e., one minus the percent of operations which are performed at the naval air station).

OLF Requirements

H.34 The required number of outlying fields, OLF, for each phase of training is computed as the ratio of required touch and go operations, TAG, to the annual OLF capacity, COLF. Equation (H.20) performs this computation:

$$OLF = \frac{TAG}{COLF} \tag{H.20}$$

Note: The above discussion assumes a single touch and go time and average number of required operations for each training phase. Should a training phase consist of several aircraft types where these factors are not similar, Equations (H.18), (H.19), and (H.20) would be recomputed for each aircraft type. The result would be an OLF requirement for each aircraft type for the particular training phase.

RUNWAY DEFICIENCY

General Methodology

H.35 The runway deficiency methodology compares runway requirements to existing (available) runways for each base. The model assumes that each available runway must be completely utilized prior to building new runways.

H.36 The method of comparison is as follows. A table listing each available runway by amount available, length, thickness factor, and composition, similar to that shown in the example for a three-runway base in Table H.2, is generated within the model. Next, a similar table that lists required runways by the same characteristics is set up within the model, as shown by the example in Table H.3. The runways are listed in the tables from longest to

TABLE H.2

AVAILABLE RUNWAYS

No	Amount	Length	Thickness	Composition
1	.84	8000	9	2
2	.84	5000	2	2
3	.60	5000	2	1

TABLE H.3

REQUIRED RUNWAYS

No	Amount	Length	Thickness	Composition
1	.70	8000	2	2
2	.50	6000	1	2

shortest. Runways of equal length are also sorted on thickness. The characteristics of runway requirement number 1 are compared to the characteristics of the first available runway. If the length[5] and thickness of the available runway are less than required, the available runway is upgraded[6] (i.e., extended in length and/or increased in thickness). If the length and thickness of the available runway are equal to or greater than required, the available runway is assumed to be adequate. Next, the amounts of the two runways are parametrically compared. If the amount available is greater than the amount required, runway requirement number 1 is satisfied, and the difference is used to satisfy, in whole or part, runway requirement number 2. Conversely, if the amount required is greater than that available, the remaining amount of requirement number 1 is satisfied to the extent possible by available runway number 2, etc. If the total amount of requirements exceed the total amount available, new runways are assumed to be built[7] until all deficiencies are eliminated.

H.37 Illustrative Example. For the data in Tables H.2 and H.3, the following calculations result. For required runway number 1, the length of 8000 ft and the thickness factor of 2 are compared to the length of 8000 ft and thickness factor 9 of the first available runway. The length of the available runway equals that of the requirement and the thickness is greater; thus available runway number 1 can be used to satisfy requirement number 1 without modification. Since the amount of the available runway, .84, exceeds the amount required, the difference of .14 is used to satisfy runway requirement 2.

H.38 Since available runway 1 can accommodate the length and thickness specified for required runway 2, the excess amount of the available runway, .14, can be used to partially fulfill the requirement. There remains .36 (i.e., .50 - .14) of requirement 2 to be satisfied.

H.39 Requirement number 2 is then compared to available runway 2 for length and thickness. In this case, the available runway must be extended 1000 ft to 6000 ft,at thickness 2.[8] The amount of the available runway, .84, exceeds the required amount and thus all requirements have been met without utilizing the third available runway.

---

[5] A tolerance of 10 feet is assumed on the available runway, so that when the available length is within 10 feet of the required, the requirement is considered to be met. Consequently, it is assumed that runway extensions of less than 10 feet are not required.

[6] The model assumes that the thickness of runway extensions is equal to or greater than the thickness of existing runways.

[7] The model assumes a primary runway is built first, next a cross-wind runway, then a primary, etc.

[8] It is assumed that an existing runway always maintains its existing thickness factor as a minimum.

AIRFIELD PAVEMENT INVESTMENT COSTS

H.40 Airfield pavement investment costs include the cost of constructing new runways, taxiways, and parking aprons, and of upgrading existing runways. The unit costs are a function of the thickness of the pavement and the material used (i.e., portland cement, bituminous), and were developed from DM-10, Cost Data for Military Construction. These unit costs were increased 10 percent for contingencies, 6 percent for design, and 50 percent for inflation since 1959 (adjustments similar to those made to facility cost factors, as discussed in Appendix I). The resulting costs per square yard associated with each thickness and material are presented in Table H.4.

H.41 The cost to build a new runway is calculated as follows:

$$NCOST = \left(\frac{(LTH)(WTH)}{9}\right)\left(\frac{(UC_{i,j})(G)}{1000}\right) \tag{H.21}$$

where NCOST = cost to build a new runway in thousands of dollars

LTH = length of runway in feet

WTH = width of runway, currently 200 ft

$UC_{i,j}$ = unit cost for runway thickness i and composition j in dollar/sq yd (per Table H.4)

G = geographic adjustment factor of .95.

The denominator 9 converts square feet into square yards, and the denominator 1000 converts costs into thousands of dollars.

H.42 The cost to upgrade an existing runway is calculated as follows:

$$UGCOST = \left[(DL)(UC_{i,j}) + (FC_i + VC_j(INCH))\ LA\right]\left[\left(\frac{WTH}{9}\right)\left(\frac{G}{1000}\right)\right] \tag{H.22}$$

where DL = incremental length in feet to be added to existing runway

FC_j = fixed cost per square yard required to increase thickness of runway; if j = 1 (concrete) FC = .70; if j = 2 (bituminous), FC = 0

VC_j = variable cost per square yard per inch of thickness required; if j = 1, VC = .65; if j = 2, VC = .84

TABLE H.4

AIRFIELD PAVEMENT COSTS AS A FUNCTION OF THICKNESS FACTOR

Thickness Factor	Cost/Sq Yd	
	Rigid Pavement (Portland Cement)	Flexible Pavement (Bituminous)
1	10.84	4.65
2	10.84	5.53
3	11.83	6.40
4	12.06	7.28
5	13.89	7.98
6	13.89	8.27
7	14.33	8.57
8	15.66	10.32
9	16.95	12.40

INCH = incremental number of inches an existing runway must be increased; i.e., difference in inches associated with the available and required thickness factors (inches are shown in Table H.5)

LA = available length in feet.

$UC_{i,j}$, WTH, G, 9, and 1000 are as defined previously. The fixed and variable costs stated above were also developed from the DM-10 document. It is assumed that when existing runways are upgraded, the same material is used in the upgrade procedure (i.e., if it was rigid, the new is also rigid pavement).

H.43 All taxiways are assumed to be built out of flexible pavement to a thickness factor of 3 as follows:

$$TAXI = \frac{(TAREA) \cdot (6.40)(G)}{1000} \qquad (H.23)$$

where TAXI = cost to build deficient taxiways in thousands of dollars

TAREA = amount of taxiways to be built in square yards

6.40 = cost per square yard of flexible pavement of thickness 3

G and 1000 are as defined previously.

H.44 All parking aprons are assumed to be built with rigid pavement of thickness factor 3 as follows:

$$PAPRN = \frac{(PAREA)(11.83)(G)}{1000} \qquad (H.24)$$

where PAPRN = cost to build deficient parking aprons in thousands of dollars

PAREA = amount of square yards of parking apron to be built

11.83 = cost per square yard of rigid pavement of thickness 3.

G and 1000 are as defined previously.

Derivation of Thickness Factors

H.45 Since pavement investment cost is directly related to thickness of pavement, thickness factors associated with aircraft type were developed for the IFRS model. (Thus the model calculates the cost of building the minimum

acceptable requirement and not necessarily a thicker standard value.) These factors range in integer values from 1.0 for the T-34B aircraft to a 9.0 for the heavier C-124 aircraft. The training aircraft currently in the inventory generally have a 1, 2, or 3 thickness factor.

H.46 The thickness factors developed are a function of five variables which determine the required thickness of a runway—aircraft weight; aircraft landing gear configuration (i.e., single or multiple); aircraft tire pressure; load-bearing capacity of runway materials (i.e., portland cement or bituminous) and their associated bases; and the load-bearing capacity of the soil at the location where the runway is built.

H.47 The data for these variables used in the development of the thickness factors were obtained from charts and graphs in the following documents:

- Aircraft weights were determined through the use of NAVAER 00-100-505, SE 210; and Aviation and Space Technology, March 1969.
- Landing gear configurations were obtained from NAVAER 00-100-505 and Jane's Aircraft.
- Aircraft tire pressures were obtained from NAVAER 00-100-505 and Jane's Aircraft.
- The load bearing capacities of aircraft pavement materials were developed from information contained in NAVFAC DM-5 and NAVFAC DM-21.
- Soil bearing capacity (average) was obtained from DM-21.

Initially, an average load bearing capacity of the soil was assumed.[9/] From this value, the load bearing capacity of the runway materials was estimated.[10/] Next, rigid pavement requirements (i.e., inches of portland cement) were developed for single[11/] and multiple landing gear loads[12/]. Finally, the rigid pavement requirements were translated into flexible pavement requirements (i.e., inches of bituminous).[13/] Table H.5 presents the IFRS thickness factor; the

---

9/ A subgrade modulus of 200 pci was assumed based on Figure 3-12 of DM 21-3027.

10/ The subgrade modulus of 200 pci translates into a California Bearing Ratio (CBR) of 10 based on Figure 4-3 of DM 5-7-8. From Figure 3-12 of DM 2-3-27, the working flexural strength of rigid pavement was assumed to be 500 psi. The design CBR of flexible pavement base and sub-base were based on an average and assumed to be 45 and 35, respectively.

11/ DM-21, Figure 3-11.

12/ DM-21, Figure 3-12.

13/ DM-21, Figures 3-6, 3-7, and 3-8.

TABLE H.5

IFRS THICKNESS FACTOR

IFRS Thickness Factor	Aircraft Weight Class	Representative Aircraft Included	Rigid Pavement (Portland Cement)		Flexible Pavement (Bituminous)		
			Surface, in.	Base, in.	Surface, in.	Base, in.	Sub-base in.
1	AA-5 and AA-10	T-34B T-28C TH-1L TH-57 H-34 T-2A/B/C	6*	10*	3	8	0
2	AA15 and AB15	TA-4J TS-2A	6	10	4	8	2
3	AA20 and AB20	A-7A TF-9J	7	10	4	8	4
4	AA-25 and AB25	A-6A E-2B	8	10	4	8	6
5	AA-30 and AB30	F-4B C-2A	9	10	4	8	9
6	AA-35	A-3B	10	10	4	8	11
7	AA-45	P-2H	10	10	4	8	12
8	AD-70	P-3C	10	12	4	8	16
9	AD-90	C-124	12	10	4	8	23

*Minimum thickness allowed.

aircraft weight classes included; the training aircraft included (or other aircraft when training aircraft did not fall into that class); the rigid pavement for portland cement surface and base; and the flexible pavement required for bituminous surface, base, and sub-base.

APPENDIX I

TOTAL SYSTEMS COST SUBMODEL

INTRODUCTION

I.1 The purpose of the Total Systems Cost (TSC) Submodel is to provide management with an estimate of the aggregate, or total, dollar resources required for alternative pilot training programs. The output of this submodel is an estimate of the total cost required to eliminate facility deficiencies, procure incremental aircraft, and maintain and operate the naval air stations and their associated pilot training phases.

I.2 Research and development expenditures and existing facilitites and aircraft assets are assumed to be sunk costs and thus excluded from this submodel. Since this submodel is an integral part of the total IFRS model, NATRACOM can estimate the TSC of alternative training programs and see how dollar requirements vary as a function of changes in various operating parameters. The TSC of new or competing training programs can then be examined to determine which training alternative minimizes the cost of training pilots. For example, if three different phase to base assignments are being considered for a 2,500-PTR, the IFRS would be exercised three times and the resulting TSCs compared to see which trial yielded the lowest cost. Although the IFRS is still a "rough cut" model, NATRACOM can use it to determine how costs change as a function of changes in pilot training operating parameters.

OVERVIEW

I.3 The TSC Submodel developed in Phase II of IFRS provides the macro, or gross, cost information required by decision makers. It should be noted that

NATRACOM utilizes resources procured from several Department of Defense appropriations. The submodel thus estimates the O&M Navy, MCON, procurement, military pay and allowances, and family housing appropriations required by the pilot training program. Since the IFRS is a management planning tool and not a budgeting tool, the appropriations are not separately identified in the model.

I.4 The cost elements of greatest importance to the decision maker were highlighted in the IFRS. The TSC Submodel is divided into the two basic cost categories: investment outlays and operations and maintenance (O&M) costs. Each of these categories is further divided into the cost elements shown in Table I.1. Investment costs are defined as one-time financial outlays for incremental capital assets for facilities and aircraft. Existing aircraft and facilities are assumed to be sunk costs. The model is currently capable of accounting for approximately 70 percent of incremental facility costs.1/ The O&M cost category includes annual estimates of military pay and allowances, fuel, aircraft support, base support, and NATRACOM fixed costs. This submodel includes both direct and indirect costs associated with the pilot training program and both training phase and NAS costs. The submodel is currently capable of providing estimates of approximately 100 percent of the annual O&M costs of the pilot training program.

I.5 This submodel is the termination of the IFRS model, i.e., it receives inputs from several preceding submodels and its output ends one complete cycle of the IFRS model. The inputs and outputs of the TSC Submodel are illustrated in Figure I.1. The prior submodel inputs to the investment cost category include the deficient facilities for each base (calculated in the Excess/Deficiency Submodel) and the total aircraft required by type (calculated in the LSR Generator). The prior submodel inputs to the O&M cost category include personnel, aircraft, and fuel requirements from the Base Loading Submodel, existing facilities from the Assets Position Data File, and deficient facilities from the Excess/Deficiency Submodel. The TSC Submodel also incorporates various planning factors and several data files that include the pertinent cost factors discussed in this appendix.

I.6 The IFRS is a management planning tool, and it can be used to estimate TSC over an extended time horizon by recycling the model. This recycling logic provides the manager with a versatile tool, since the pilot training program often changes from year to year. Thus, the model estimates annual incremental facility and aircraft costs and total annual O&M costs. For example, in a 5-year plan to increase PTR by 10 percent annually, an incremental facility and aircraft investment cost would probably occur each year and annual O&M costs would also increase for each of the 5 years. The model is designed so that when new facilities are built the amount built is temporarily added to the data file of existing facilities so that the same facility is not recorded as having been built more than once.

I.7 Typical sample outputs of the IFRS Phase II TSC Submodel appear in Table I.2 and illustrate the types of information provided to the decision maker.

1/ Based on the number of facilities included in the model.

TABLE I.1

IFRS TOTAL SYSTEMS COST ELEMENTS

Investment

- Facilities
- Aircraft

Annual Operation and Maintenance

- Military Pay and Allowances
- Fuel
- Aircraft Support
- Base Support
    - Facility Maintenance
    - Civilian Wages
- NATRACOM Pilot Training Fixed Costs

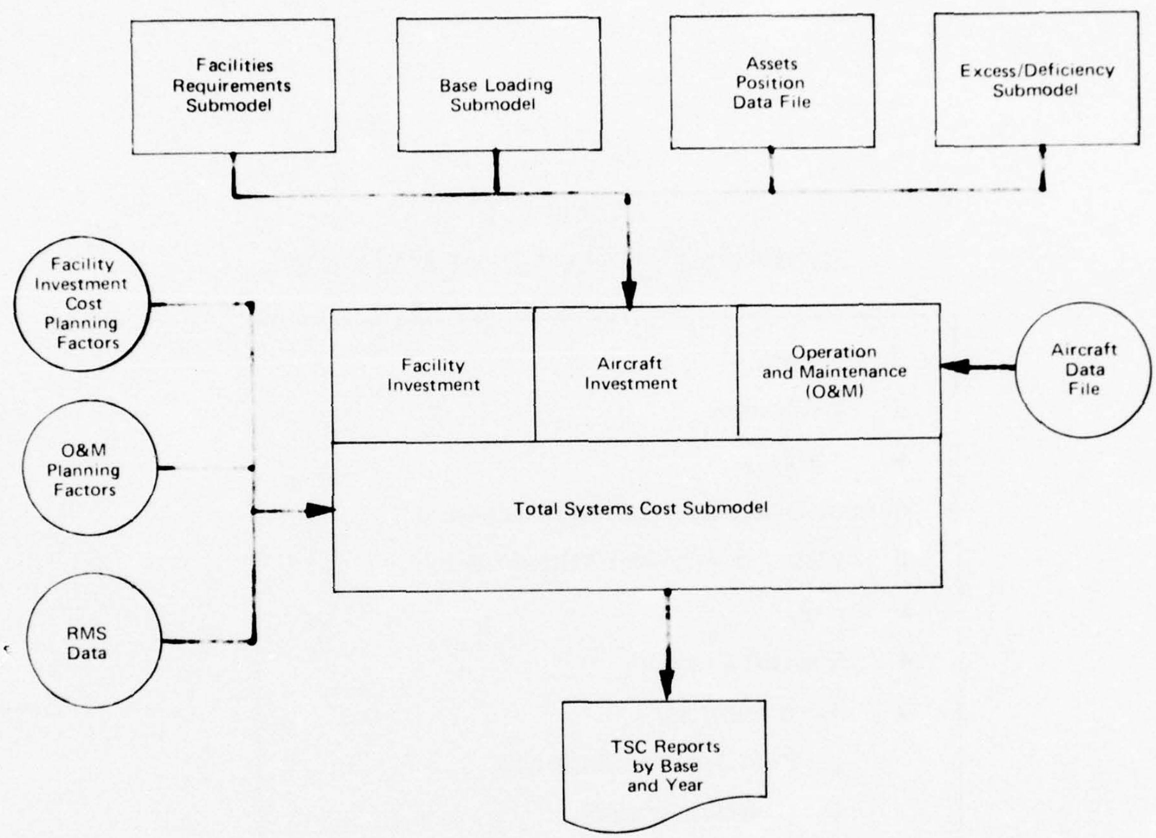


FIGURE I.1. TSC SUBMODEL INPUTS AND OUTPUTS

TABLE I.2

SAMPLE TOTAL SYSTEMS COST PRINTOUTS

a. Facility Investment Cost

	NAS TOTAL
YEAR 1970	136123.3

b. Aircraft Investment Cost

A/C INVESTMENT & ASSET POSITION---CNATRA

A/C	ASSET POSITION AVAILABLE	REQ'D	DEFICIT	------ COSTS (THOUS.) ---- FLYAWAY	SUPPORT	TOTAL
T34B	150.	149.	0.	0.	0.	0.
T28C	469.	388.	0.	0.	0.	0.
T-2A	114.	112.	0.	0.	0.	0.
T2BC	178.	183.	5.	2740.	411.	3151.
TF9J	399.	196.	0.	0.	0.	0.
TA4J	100.	176.	76.	83809.	12571.	96381.
TS2A	179.	188.	9.	18103.	2715.	20818.
THIL	0.	62.	62.	24732.	3710.	28441.
TH57	34.	25.	0.	0.	0.	0.

c. O&M Cost

SUMMARY O & M COSTS

NAS	MILITARY P&A	A/C FUEL TOTAL	A/C O&M TOTAL	BASE SUPPORT	TOTAL
CHAS	16459.5	6009.5	3750.9	3630.3	29850.1
CORP	28110.4	2625.3	1919.5	12514.4	45169.7
ELLY	8921.8	522.9	372.6	2251.1	12068.4
KING	17258.3	7547.1	2651.8	3797.5	31254.8
MERI	20878.3	5808.5	1972.8	4256.2	32915.8
PENS	29650.4	2482.7	591.6	14372.0	47096.7
SAUF	15866.8	472.1	394.0	3219.1	19952.0
WHIT	23284.6	1747.0	1155.6	4628.3	30815.5

TOTAL O & M COST
ALL BASES 249122.9

TOTAL SYSTEMS COST =
FACILITY INVESTMENT COSTS
+ A/C INVESTMENT
+ O & M COSTS (LESS NON ADD ITEMS)
+ CNATRA, CNABATRA, CNAVANTRA --- FIXED COSTS
--------- 540662.3

An estimate of the gross dollar amount required to eliminate facility deficiencies for each NAS is output as shown in the table. Next, the aircraft investment cost print-out is generated for the total pilot training program but not for a specific base. Then for each NAS, the O&M cost for military pay and allowances, aircraft fuel, aircraft support, base support and total O&M costs, and finally, the TSC for the pilot training program are output.

I.8 In its present "rough" state, the IFRS II model provides a good estimate of the aggregate dollar amounts required by each pilot training program. The methodology used to develop these costs and the data sources employed are discussed in the remainder of this appendix.

INVESTMENT COST CATEGORY

I.9 Investment costs are defined as one-time financial outlays for incremental capital assets of facilities and aircraft required by the pilot training program. The costs of existing facilities and aircraft are assumed to be sunk costs. In IFRS Phase II, 24 facility types are included in the submodels; thus, 24 cost estimating relationships (CERs) were developed to predict the cost of correcting NAS facility deficiencies. Using data for these 24 facilities, the model can predict approximately 70 percent of the incremental facility investment cost that would be required by MCON appropriations. This capability of the submodel and the methodology estimating the total facility cost of building a completely new base are discussed in this subsection.

Facility Investment CERs

I.10 The cost estimates developed by means of the submodel reflect average costs for all military construction; hence, such costs as extensive site preparation and demolition are not included. These costs are a function of individual base characteristics and cannot be handled within the scope of the current effort.

I.11 The facility CERs were developed using the following data sources:

- Department of Defense, The Military Construction Cost Review Guide, FY 71
- U.S. Air Force, Military Construction Pricing Guide, AFP 88-16, 26 May 1969
- Department of the Navy, Bureau of Yards and Docks, Cost Data for Military Construction, DM-10, June 1961.

I.12 The Department of Defense document was the primary source of data on facilities costs; the Air Force document was the secondary source; and DM-10 was the tertiary source in the CER development. The DM-10 cost figures were inflated to 1 January 1969 price levels.[2/] The static time period for all unit costs is January 1969.

[2/] Based on construction cost indices contained in Engineering News Record, March 1969.

I.13 Estimates of facility investment costs are developed in this section for all facilities included in the Facilities Requirements Submodel. The development of structure and utility CERs is discussed in this appendix. The analysis used in developing the air field pavement cost is discussed in Appendix H.

I.14 Structure and Utility CERs. Construction costs of structures and utilities reflect, in general, the estimated contract cost to the government for a complete facility to the five foot line, including the cost of air conditioning to the extent authorized.[3] Unit costs obtained from the three documents cited above were increased by a factor of 10 percent to account for contingencies. An additional factor of 6 percent was included to account for engineering, supervision, inspection, and administration costs.[4] The resultant unit cost is used in the investment cost model. In addition to the foregoing adjustments, the derived CERs also contain the following factors.

- Facility support costs outside the five foot line
- Design cost
- Size unit/cost adjustment[5]
- Geographic location factor
- Cost-time relationship (to inflate costs for future years).

These adjustments yielded a representative CER in the following form.

$$TC_i = (NU_i)\ (UC_i)\ (FSF_i + DF_i)\ (Y_i)\ (T)\ (G) \qquad (I.1)$$

where TC_i = total investment cost for facility type i

NU_i = number of units of facility type i to be constructed

UC_i = unit cost of facility type i already adjusted for 10 percent contingencies and 6 percent engineering, supervision, inspection, and administration (to five foot line only)

FSF_i = facility support factor for type i facility

3/ Department of Defense, Construction Criteria Manual, 4270.1M.

4/ As suggested in Department of Defense, The Military Construction Cost Review Guide, FY71, and U.S. Air Force, Military Construction Pricing Guide, AFP 88-16, 26 May 1969.

5/ Department of Defense, The Military Construction Cost Review Guide, op.cit., p.6.

DF_i = design factor of 6 percent divided by 1.06

Y_i = size-cost adjustment factor

T = cost-time adjustment factor

G = geographic adjustment factor.

I.15 Facilities support costs. These costs are incurred when integrating facilities into the total base structure, e.g., sidewalks and lawns.

I.16 Design costs. These include the cost of designing the facility and are estimated at 6 percent of the cost to the five foot line plus contingencies. Since the unit costs contain an allowance of 6 percent for engineering, supervision, etc., unit cost must be deflated by 6 percent before calculating design cost, i.e., divide unit cost by 1.06, then calculate design cost.

I.17 Size/unit cost adjustment. Such adjustment is required due to engineering considerations. It is cheaper, on a per unit basis, to construct large rather than small buildings. The Department of Defense supplies a size/unit cost adjustment chart which adjusts unit costs to reflect this fact (see Figure I.2).[6/] Since the IFRS model is computerized, an approximation of this curve was calculated for use in the cost formula. The curve supplied by the Department of Defense was found to be of the form:

$$Y = CX^m \tag{I.2}$$

where Y = the cost relationship

X = the area relationship

C and m are parameters.

X is calculated by dividing the actual size of a building by the typical size of that type of building. If no typical size is available, X is assumed to equal 1.0. The appropriate formulae are:

for X < 1.0 (a building less than typical size)

$$Y = 1.007\ X^{(-.10085)} \tag{I.3}$$

for X = 1.0 (a building of typical size)

$$Y = 1.0 \tag{I.4}$$

6/ Ibid.

for $X > 1.0$ (a building greater than typical size)

$$Y = 1.0012\, X^{(-.06329)} \qquad (I.5)$$

where 1.007, -.10085, 1.0012, and -.06329 are parameters of the relationship in Figure I.2. The resulting Ys are the cost/size adjustment factors included in the total cost formula.

I.18 Geographic adjustment factor. This factor allows for the differing costs of construction in various parts of the country. For all the NATRACOM pilot training bases the factor is .95.

I.19 Cost time relationship. This factor allows for the updating of the CERs for future years. The unit costs are calculated in 1969 dollars. To run the model for future years, a provision for a construction inflation factor is included. The appropriate factor from price indices should be inserted as the value of this factor. At present the CERs contain 1.0 as the inflation factor, since the magnitude of future price increases is uncertain.

I.20 The unit cost, typical size, and facility support factors for the 20 structures and utility facilities appear in Table I.3. The range in size of ready fuel storage tanks and the costs associated with each size are shown in Table I.4.

I.21 Sample calculation. For an example of the use of Table I.3 and the foregoing CERs, assume the Excess/Deficiency Submodel calculates that NAS Pensacola has a 100,000-sq ft deficiency in aircraft maintenance hangars. The parameters for the preceding equations are obtained from Table I.3 and the equation becomes:

$$TC = (100{,}000)\ (23.10) \left[1.15 + \left(\frac{.06}{1.06}\right)\right] (.95)\ (1.0)\ (.95).$$

The resultant total cost, TC, for this deficient facility is \$2,515,489. The \$23.10/sq ft unit cost and the 1.15 support factor are obtained directly from Table I.3. The 50,000 sq ft typical size is obtained from Table I.3, and the size cost adjustment factor developed as follows:

$$X = \frac{100{,}000}{50{,}000} = 2$$

$$Y = (1.0012)\ (2)^{(-.06329)} = .95$$

The value of Y can also be obtained from the curve in Figure I.2. It is assumed that the inflation factor, T_1 is 1.0.

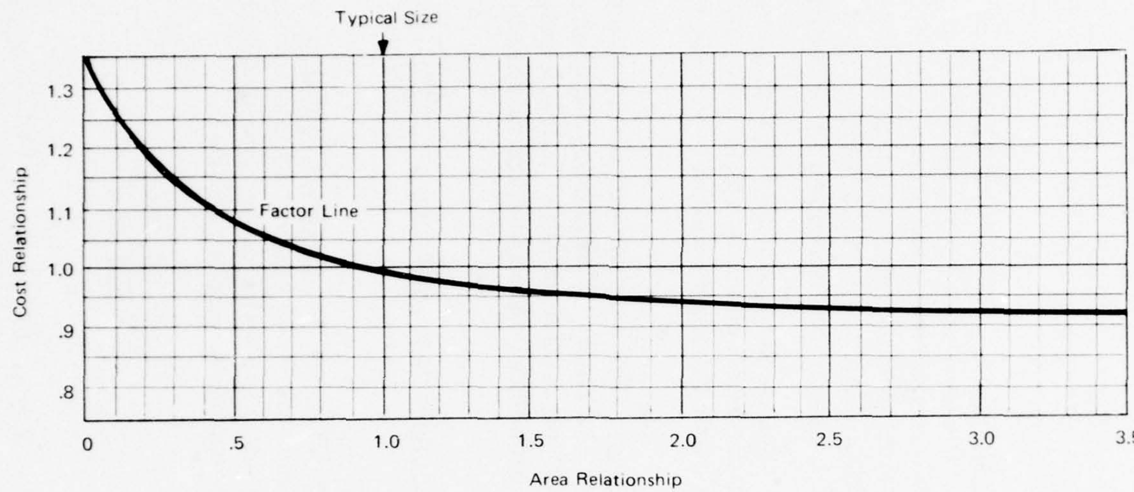


FIGURE I.2. SIZE/UNIT COST ADJUSTMENT CHART

TABLE I.3

FACILITY INVESTMENT CER FACTORS

Category Code	Facility Name	Unit of Measure	Cost per Unit (January, 1969)	Typical Size	Facility Support Factor	Source of Cost	Comments
124-30	Ready Fuel Storage	Tank	Function of Tank Size	N/A	N/A	AFR 88-16	See Table I.4 for available tank sizes and costs
125-40	Underground Fuel Distribution Lines	LF	12.00	N/A	N/A	AFP-88-16	8 in.diameter assumed in model
136-30	Runway Lighting	LF	34.50	N/A	N/A	AFP-88-16	High intensity 200 W lighting assumed
	Runway Lighting	No. of Runway Ends	69,000	N/A	N/A	AFP-88-16	Runway lighting includes configuration lighting at each end
141-40	Aircraft Operations Building	SF	39.60	13,000	1.17	DOD Document	
171-10	Academic Building	SF	24.10	25,000	1.12	DOD Document	
211-10	Maintenance Hangar	SF	23.10	50,000	1.15	DOD Document	
219-10	Public Works Maintenance Shop	SF	22.00	5,260	1.23	AFP-88-16	
422-10	General Warehouses	SF	9.00	N/A	1.15	DOD Document	
550-10	Dispensaries	SF	38.00	N/A	1.14	DOD Document	
610-10	Administrative Offices	SF	25.40	15,000	1.12	DOD Document	
711-10	Family Housing*	No. of Housing Units	21,500	N/A	N/A	HR 12171	Statutory limit, 91st Congress, January 1969
722-10	Enlisted Men's Barracks	No. of Men	2,900	N/A	1.10	DOD Document	
723-10	Enlisted Men's Mess	SF	33.50	15,000	1.18	DOD Document	With 2-4 day storage
724-15	Bachelor Officers' Quarters	No. of Men	10,000	N/A	1.17	DOD Document	With/Without Mess
740-14	Exchange With/Cafeteria	SF	25.80	21,000	1.15	DOD Document	
740-63	Enlisted Men's Service Club	SF	26.70	16,000	1.13	DOD Document	
812-30	Electric Power Distribution Lines	LF	5.75	N/A	N/A	AFP-88-16	Overhead lines
842-10	Potable Water Distribution Lines	LF	10.90	N/A	N/A	AFP-88-16	10 in.diameter cast iron pipe assumed
851-10	Roads	MI	71,595	N/A	N/A	DM-10	6 in. AC on stabilized ground assumed, 24 ft width assumed
852-10	Parking Areas	SY	4.30	N/A	N/A	DM-10	2 in. bituminous on 7 in. earth base assumed

* The Department of Defense does not construct houses for ineligible personnel, and thus no CER was developed.

TABLE I.4

READY FUEL STORAGE TANK SIZES

Tank Size, gallons	Cost Per Tank, dollars
Underground	
1,000	1,200
2,000	2,300
3,000	3,300
4,000	4,200
5,000	5,000
6,000	5,700
8,000	7,200
10,000	8,500
12,000	9,600
15,000	11,250
20,000	14,000
25,000	16,250
30,000	18,000
50,000	25,000
210,000	40,500
Above Ground	
315,000	57,000
420,000	58,000
630,000	76,500
840,000	92,000
1,050,000	102,500

I.22 Table I.5 shows a detailed hypothetical printout of the facility costs for NAS Meridian. Assuming that all facility deficiencies are to be corrected at this NAS, the total output gives an estimate of the MCON funds required. In actual practice, these funds would be allocated over several years. The flexibility of the facility investment cost model provides the time-share operator with the option to build all, part, or none of each facility by line item simply by typing in the appropriate data as shown at the bottom of Table I.5.

I.23 Phantom Base Facility Costs. As stated previously, the facility costs contained in IFRS cover approximately 70 percent of total facility replacement investment costs on the average for all eight bases included in the pilot training program.[7/] If a completely new, or phantom, base is to be built to train pilots, additional support facilities will have to be built for the new base, and they must be costed. To estimate the total facility cost, the total cost estimates obtained for the 24 facilities costed in the IFRS model must be divided by 0.70.

Aircraft Investment CERs

I.24 This cost includes both flyaway and initial provisioning costs for training aircraft. Even though these costs are funded by NAVAIRSYSCOM, they are included in the IFRS since these aircraft are resources used in conducting the pilot training program. Flyaway cost is the cost of an aircraft ready to fly, including the cost of government furnished equipment.

I.25 Estimates of Flyaway Costs. These estimates were obtained for aircraft currently available for purchase by the Navy and are shown in Table I.6. The costs are dependent upon the current production status of a particular aircraft, and the data currently in the model indicate order of magnitude. Two aircraft, the T-34 and T-28 are currently out of production, and their hypothetical flyaway costs reflect the higher production startup costs that might be required for a new production run. The TS-2A is also out of production and will probably be replaced by a new aircraft. The factor included for it, therefore, reflects the higher costs expected for the new aircraft. The aircraft investment cost data are stored in the Aircraft Data File.

I.26 The number of training aircraft to be procured is calculated by comparing the number of aircraft required to the current NATRACOM aircraft inventory. If aircraft requirements exceed the existing inventory, the models assume these aircraft are purchased. Aircraft requirements are computed in the LSR Generator and include provisions for aircraft in A-3 operational status as well as aircraft undergoing basic and intermediate maintenance conducted at the base. However, to estimate total requirements, LSR generated requirements are increased by a factor of 15 percent to account for aircraft undergoing progressive aircraft rework and overhaul. The inventory of aircraft of each type available

---

7/ See Facilities Requirements Submodel for derivation of 66 percent.

TABLE I.5

SAMPLE PRINTOUT OF FACILITY INVESTMENT COSTS, NAS MERIDIAN

```
NAS--MERI
  FACILITIES
 DETAILED BREAKDØWN (Y,N)?Y

11320 TØT PKNG APN      693.8
12540 DIST PIPELIN       68.4
14140 AC ØP BLDG        244.0
21110 MAINT HANGAR     2467.0
21910 PW MAINT SHP       14.2
44210 TØT WAREHSE       412.5
71110 FAM HØUSING     12096.5
72415 BØQ               651.3
74063 SERVICE CLUB      179.6
81230 ELEC DIST LN       43.1
85110 RØADS             439.5
85210 PARKING AREA       46.0

       BASE TØTAL     17355.9
```

TABLE I.6

AIRCRAFT FLYAWAY COSTS*

Aircraft Type	Flyaway Cost, dollars
Primary Trainer (T-34)	40,000**
Basic Prop (T-28)	500,000**
Advanced Prop (TS-2A)	2,000,000**
Basic Jet Trainer (T-2C)	600,000
Advanced Jet (TA-4F)	1,100,000
Basic Helo (TH-57A)	115,000
Advanced Helo (TH-1L)	400,000

*Source: Mr. Tim E. Connors, NAVAIRSYSCOM.

**Aircraft not currently in production. These cost estimates are based on hypothetical startup production costs.

to NATRACOM is stored in the Aircraft Data File, as derived from the total listing of aircraft[8] for each of the eight bases under study. It should be noted that the names as listed under the aircraft column of Table 1.6 are the most common designations for the aircraft types, and that similar aircraft are listed under one designation if they are being utilized for the same phase of training. The aircraft deficiencies are calculated by type of aircraft as follows:

$$DEFAC_j = TOTAC_j - CNAAC_j \qquad (I.6)$$

where $DEFAC_j$ = deficient A-3 training aircraft type j

$TOTAC_j$ = training aircraft of type j required (calculated in LSR Generator and increased 15 percent)

$CNAAC_j$ = NATRACOM aircraft type j available.

The flyaway cost for each type aircraft is then:

$$COST1_j = (DEFAC_j)\ (FLCST_j) \qquad (I.7)$$

where $COST1_j$ = total flyaway cost for deficient aircraft type j

$FLCST_j$ = flyaway cost of aircraft type j (stored in Aircraft Data File).

I.27 Initial provisioning cost includes an allowance for initial spares and spare parts, special support equipment (SSE), and other support required to bring a new aircraft into NATRACOM. The initial spares and spare parts include those items funded by NAVAIRSYSCOM that are required to fill the supply pipeline for each new aircraft. SSE is the nonflying equipment peculiar to a particular aircraft and required to maintain the aircraft. Other support includes costs for such items as publications and technical representatives. Initial provisioning cost is a function of the number of bases to which an aircraft is deployed and the degree of sophistication of the aircraft. Since training aircraft are generally deployed to few bases and since they do not require sophisticated navigation equipment and fire control systems, their provisioning cost is less than that required for combat aircraft. Initial provisioning costs based on information provided by NAVAIRSYSCOM personnel[9] vary from

---

8/ Facilities, Personnel, and Aircraft Summary, January 1969. (Unofficial publication.)

9/ Mr. Mel Wade and Mr. Tim E. Connors, NAVAIRSYSCOM.

approximately 17 percent of flyaway costs for completely new training aircraft to 8-12 percent of flyaway for aircraft currently in the inventory. For the purposes of this study, a factor of 15 percent of flyaway cost was considered appropriate and was used. Hence, the total costs of initial spares and spare parts, SSE, and other support are estimated by multiplying the flyaway costs, COST1, by 15 percent.

ANNUAL OPERATIONS AND MAINTENANCE COST CATEGORY

I.28 Annual O&M costs include financial outlays required to maintain and operate the NATRACOM pilot training program.[10] O&M costs are recurring and continue throughout the life of the pilot training program. Since the pilot training program often changes annually, each year's O&M costs are estimated separately. The IFRS model is run for each future year on the basis of projected pilot training programs for those particular years. If one assumes a static pilot training program, the annual O&M costs could simply be multiplied by the number of years to be costed. The O&M cost category is composed of the following cost elements.[11]

- Military pay and allowances
- Aircraft fuel
- Aircraft support
- Base support
- NATRACOM pilot training fixed costs.

The methodology developed for each of the cost elements is discussed in the following paragraphs.

Military Pay and Allowances

I.29 This cost element represents the annual amount of basic pay and allowances required for military personnel assigned to the pilot training program. The cost of pay and allowances is determined by applying appropriate factors to the number of students, training phase officers and enlisted men, and NAS officers and enlisted men. Annual pay and allowances, in dollars, for each category of military personnel are presented in the following listing.[12]

---

[10] Includes cost of training squadrons and NASs.

[11] O&M costs associated with aircraft carriers used in the pilot training program are not included.

[12] The source of the military pay and allowance factors is NAVCOMP Notice 7041, 28 May 1969. Estimates of flight pay were obtained from the 1969 World Almanac published by the Washington Daily News.

Training Phase	Annual Pay, dollars
Officers	15,771 [13/]
Enlisted	5,849
Students	8,411 [13/]
Naval Air Station	
Officers	13,911
Enlisted	5,849

I.30 The foregoing figures represent Navy averages. The model assumes that all training phase officers, including administrative officers, receive flight pay. This assumption may result in a small overestimate of pay and allowances for training phase officers, since all administrative officers do not necessarily receive flight pay. It is assumed further that all students, regardless of source, are in pay grade 0-1 and receive a basic pay of $7,211 per year plus $1,200 per year in flight pay. The number of military men receiving pay and allowances is an output of the Base Loading Submodel. The number of students is the average student load.

I.31 The equation used to calculate military pay and allowances for NAS officers is:

$$COST_i = PHPER_i \ (13.911) \qquad (I.8)$$

where $COST_i$ = total annual military pay and allowances for NAS officers assigned to base i

$PHPER_i$ = total number of officers required at base i as calculated in Base Loading Submodel.

The constant, 13.911, represents average annual pay and allowances for officers (in thousands of dollars).

Aircraft Fuel

I.32 The annual cost of fuels and lubricants is estimated as a function of total annual fuel consumption. The total annual fuel consumption for each fuel type is an output of the Base Loading Submodel and is calculated as a function of total annual flight hours and fuel consumption rate by aircraft type.

I.33 The estimated annual amount of fuel consumed by NAS aircraft is stored in the Base Data File and is added to the training aircraft fuel consumption in

13/ Includes annual flight pay of $1,860 for training phase officers and $1,200 for students

the Base Loading Submodel. The cost per gallon of fuel consumed [14/] is as follows:

JP-4	12.7 cents/gallon
Aviation Gas	17.0 cents/gallon
Helo Gas	17.0 cents/gallon

The helo gas is assumed to be the same as the aviation gas cost. The fuel cost is calculated by the following equation:

$$COST3_i = (FUREQ_{i,1})\ (.127) + (FUREQ_{i,2})\ (.17) + (FUREQ_{i,3})\ (.17) \qquad (I.9)$$

where $COST3_i$ = total fuel cost for base i

$FUREQ_{i,1}$ = total jet fuel, including training phase and NAS, consumed at base i (calculated in Base Loading Submodel)

$FUREQ_{i,2}$ = total aviation gas consumed at base i

$FUREQ_{i,3}$ = total helo gas consumed at base i

.127, .17, and .17 = cost per gallon of each fuel type.

Aircraft Support

I.34 The recurring spares, spare parts, and consumables required to maintain and operate training aircraft are included in this cost element. This cost is estimated by multiplying the cost per flight hour by the annual flight hours for each aircraft type as follows:

$$ACOST_j = (ACREQ_j)\ (ACFH_j)\ (AOM_j) \qquad (I.10)$$

where $ACOST_j$ = annual aircraft support cost for aircraft type j

$ACREQ_j$ = A-3 operational type j aircraft required

$ACFH_j$ = annual flight hours for aircraft type j

AOM_j = cost per flight hours for aircraft type j.

I.35 The annual flight hours for each aircraft type are calculated in the LSR Generator. The cost per flight hour is included in the Aircraft Data File. It

---

14/ Source: Cdr. R.E. Loux, Aircraft Programs Branch, Aviation Programs Division, Deputy Chief of Naval Operations.

should be noted that currently the IFRS contains only the cost of consumables funded by NATRACOM and contained in the following listing.

Aircraft	Consumable Cost per Flight Hour, dollars 15/
T-34	2.57
T-28	5.78
T-2A	13.01
T-2B/C	16.51
TA-4J	37.68
TF-9J	25.89
TS-2A	14.89
TH-57	1.61
UH-34	12.44
TH-1L	10.50

The cost data on recurring spares and spare parts funded by NAVAIRSYSCOM are classified and thus not included in the IFRS.16/

Base Support

I.36 The Base Support cost is an estimate of the total O&M Navy funds expended by the NASs that support the pilot training program. These costs arise from several air station functions, i.e., administration, supply operations, maintenance of material, property disposal, medical operations, base services, maintenance of real property, utility operations, engineering support, minor construction, and personnel support. The data used to estimate this cost are drawn from the Resource Management System (RMS) reports.

I.37 The historical RMS expenditure data included in NAVCOMPT Report 7000-8 could not be used directly to estimate the O&M cost associated with training squadrons and bases, since there appeared to be a lack of consistency in the data. The RMS data are presented by cost generating centers, by functional/subfunctional categories, and by element of expense (input) generating the cost. However, there was more consistency in the FY 69 annual planning data in the CNATRA 7000-4 reports, and these were used to estimate the gross base costs. Military personnel costs were deleted from the total annual planned expenditures for the eight pilot training bases, since these are calculated separately,as discussed previously.

I.38 A CER was developed to estimate the total base support cost for each NAS based on regression techniques17/ and the FY 69 RMS planning data. This

---

15/ Data obtained from RMS on Program VIII-811147-FY 1969.

16/ Office of the Chief of Naval Operations, Navy Program Factors (U), OPNAV-90P-02, Group 4, rev. 1 January 1970, CONFIDENTIAL.

17/ See Appendix K for a discussion of regression analyses used.

CER relates base support cost to the total number of training phase and tenant personnel on base as follows:

$$BSUPP_i = 1246.13 + 1.42612\ (TBAS_i - TNAS_i) \tag{I.11}$$

where $BSUPP_i$ = annual expenditure for base support at base i, in thousands of dollars

$TBAS_i$ = total base personnel including training phase, tenants, and NAS for base i (as calculated in Base Loading Submodel)

$TNAS_i$ = total NAS personnel for base i (as calculated in Base Loading Submodel).

Equation I.11 has a correlation coefficient greater than .95 and the coefficients are significant with 90 percent confidence per t test. The base support associated with individual bases may be higher than the actual level in some cases and lower in others due to the use of the regression equations. In the aggregate, for all bases, however, the predicted base support cost should be very close to the actual value. It is assumed that all non-reimbursable O&M costs incurred by each NAS are charged to the pilot training program. To the extent that this assumption does not hold true, the base support cost estimate will tend to be greater than that actually required to support the pilot training program. On the basis of available data, the existence of economies of scale and the distinction between fixed and variable costs could not be ascertained. Unless the functional relations generating costs are identified, the relationship between O&M costs (fixed and variable) and pilot training program change cannot adequately be evaluated.

I.39 Facility Maintenance Cost. As stated previously, the RMS data did not permit the identification of detailed O&M costs. It was deemed appropriate to provide management with an estimate of facility maintenance cost by line item. However, facility maintenance costs are included in the base support costs previously discussed. These facility costs are estimated on the basis of Navy planning factors, but are not summed in the TSC, thus preventing double accounting. Standard Navy direct labor and material costs for all facilities included in the IFRS are shown in Table I.7.

I.40 The estimates of maintenance unit costs reflect the allocation of given maintenance budgets for recurring maintenance costs, and not necessarily the costs required to meet desired maintenance needs. Certain facilities did not have

TABLE I.7

FACILITY MAINTENANCE COST FACTORS*

Facility	Direct Labor & Material Cost, $/unit
Runways	.02/sq yd
Taxiways	.02/sq yd
Parking Aprons	.02/sq yd
Ready Fuel Storage	.09/gal
Underground Fuel Distribution Pipeline	.08/ft
Runway Lighting	.14/ft
Aircraft Operations Building With Tower	.19/sq ft
Academic Buildings (All Types)	.19/sq ft
Maintenance Hangar	.19/sq ft
Public Works Maintenance Shops	.19/sq ft
General Warehouse	.06/sq ft
Dispensaries	.26/sq ft
Administrative Offices	.22/sq ft
Family Housing (All Types)	419.00/unit **
Enlisted Men's Barracks	26.25/man
Enlisted Men's Mess Halls	.21/sq ft
Bachelor Officers' Quarters	105.00/man
Exchange With Cafeteria	.16/sq ft
Enlisted Men's Club	.16/sq ft
Electric Power Distribution Lines Overhead	.08/ft
Potable Water Distribution Lines	.08/ft
Roads	986.00/mile
Parking Areas	.04/sq yd

* Source: Unit expenditure data from Navy-wide unit expenditures, recurring maintenance, and other engineering support, NAVFAC, "FY 1971 O&M Facilities Management Resources Budget Guidance Rationale."

** The model currently assumes that both government and private houses are maintained by the Navy and thus, this factor is excluded from the model.

standard planning factors, and the maintenance costs associated with them were estimated in the following manner. It was assumed that the maintenance cost for ready fuel storage is 1 percent of the total current plant value per gallon. Similarly, it was assumed that the maintenance cost per linear foot of runway lighting is 1 percent of current plant value per foot. It was assumed that the cost for maintenance of underground fuel distribution lines is the same as that for potable water distribution lines. The maintenance cost of BOQs and EM barracks had to be expressed in dollars per man to be compatible with the IFRS units of measure. Thus, the standard Navy planning factor of 21 cents per sq ft was multiplied by the assumed area occupied by the men (125 sq ft for enlisted and 500 sq ft for officers).[18] The factor per mile of road was obtained by multiplying the 7 cents per sq yd by the assumed 14,082 sq yd in a mile of road. Maintenance costs for Navy housing are the Navy average costs for housing within CONUS.[19] These unit costs are increased in the IFRS to reflect costs of maintenance shop overhead, maintenance control division, emergency service work, and others as follows:

$$M_i = (FAC_i)\ (X_i)\ (1 + ES + MSO + CME) \qquad (I.12)$$

where M_i = total facility maintenance cost for facility type i

FAC_i = total amount of facility type i located at each NAS (i.e., total in assets position data file plus incremental deficiencies that are corrected)

X_i = direct labor and material cost for facility type i included in IFRS model

ES = percent of X_i required for emergency service work; equals 12.7 percent

MSO = percent of X_i required for maintenance shop overhead and maintenance control division; equals 26 percent

CME = percent of X_i required for construction, maintenance, and equipment cost; equals 1.9 percent.

I.41 Civilian Wages. Since the IFRS estimates the number of civilian personnel required at each base, it was deemed appropriate to provide an estimate of the cost of civilian wages. Since civilian wages are included as part of

---

18/ The space used is the maximum permitted by present Navy civil engineering factors contained in NAVFAC P-80.

19/ Obtained from Mr. W.W. McMillan, NAVFAC, Family Housing Branch.

base support costs[20] these wages are estimated as a non-add item similar to facility maintenance cost in the following manner.

$$COST1_i = (PHPER_{ij})\,(7,000) \qquad (I.13)$$

where $COST1_i$ = annual civilian wages at base i

$PHPER_{ij}$ = number of civilian at base i (calculated in Base Loading Submodel).

Average annual wages for naval air station civilians, in dollars, are represented as \$7,000. [21]

NATRACOM Pilot Training Fixed Costs

I.42 The annual O&M costs required by the CNATRA, CNABATRA, and CNAVANTRA staffs are included in the TSC Submodel as a fixed cost of \$6.2 million. These are essentially managerial costs required to maintain and operate the pilot training program and should not vary drastically with changes in the pilot training program. So that the model can estimate approximately 100 percent of the TSC for pilot training, it was necessary to include these fixed costs.

Sample Detailed Printout of O&M Cost Elements

I.43 A sample detailed printout of the O&M cost elements for NAS Meridian is provided in Table I.8. First, the non-add items of facility O&M cost, by line item and civilian wages, are shown. (It should be noted that these dollar amounts are included as part of base support and thus are not added into the total.) Next, the military pay and allowances for phase officers, phase enlisted men, students, NAS officers, and NAS enlisted men are given. The aircraft fuel and support costs and finally the base support cost are shown. The total annual O&M cost for the NAS appears at the bottom.

20/ By deleting civilian wages from base support cost, the index of determination of the regression equation was too low to be acceptable. Consequently, base support costs are estimated including civilian wages.

21/ Based on historical FY 69 civilian wage data, including 8 percent benefit, provided by M. Tompkins, RMS, NATRACOM.

TABLE I.8

SAMPLE DETAILED OPERATIONS AND MAINTENANCE PRINTOUT, NAS MERIDIAN

```
-----------------------
NAS--MERI
11320 TOT PKNG APN        9.8
12540 DIST PIPELIN        1.7
14140 A/C OP BLDG         4.5
17110 ACADEMC BLDG        8.0
21110 MAINT HANGAR       59.5
21910 PW MAINT SHP        2.5
44210 TOT WAREHSE        11.2
55010 DISPENSARY          7.2
61010 ADMIN OFFICE       15.9
72210 EM BARRACKS        42.4
72310 EM MESS HALL        5.7
72415 BOQ                48.1
74014 EXCHANGE            4.2
74063 SERVICE CLUB        2.9
81230 ELEC DIST LN       13.0
84210 WATER DIS LN        8.1
85110 ROADS              27.2
85210 PARKING AREA        4.7
11110 RUNWAYS            10.0
*  SUBTOTAL             286.8

*  CIVILIAN WAGES      2710.0

PAY & ALLOWANCES
  PHASE OFFICERS       4700.2
  PHASE ENLISTED       8074.3
  STUDENTS             3559.5
  NAS OFFICERS          999.3
  NAS ENLISTED         3545.0
   SUBTOTAL           20878.3

A/C FUEL               5808.5
A/C O & M              1972.8
BASE SUPPORT           4256.2
   TOTAL              32915.8
```

APPENDIX J

PERFORMANCE MODEL[1/] FOR THE NAVAL AIR TRAINING COMMAND

INTRODUCTION

J.1 The Naval Air Training Command can be viewed as a "producer"— it produces Navy pilots. All producers face the same basic economic problem of how to achieve a desired level and quality of production at a minimum cost. Optimum allocation of limited resources (funds) is required to achieve the highest production and quality level possible. Certain minimum levels of product quality must be achieved, and specified maximum levels should not be exceeded. Violating either constraint leads to a non-optimum position. With limited resources, increases in product quality may be achieved at the expense of quantity produced.

J.2 The performance model can assist in the achievement of optimum allocation of resources. It is a tool for evaluating and balancing the pilot production system in terms of quality and volume of output. It provides a framework for analyzing the influence of the several factors which may impinge upon output quality and volume, and the potential effects of alternative management decisions. For example, several crucial issues must be at least considered with regard to product quality. Two such issues, which may or may not have a direct bearing, are personnel morale and safety expenditures. It may be found that these two elements can be reduced for very short periods without impairment of the quality of output (Navy pilots). However, if these elements are degraded over protracted periods (however defined), the output quality may be severely impaired.

1/ The Performance Model was developed by Mr. Dennis Whang, of the Systems Analysis Division of NAVFAC, as part of the IFRS study.

J.3 The performance model proposed herein is an analytical framework that can be used to reflect CNATRA's preferences and the cost associated with the various weighting systems he chooses to use to express his preference. Thus, the proposed analytical framework has a built-in flexibility to cope with changes in preference dictated by changes in the force level, the level of funding, and/or other exogenous variables. However, specification of values in the model and development of the weighting systems must remain CNATRA's responsibility.

ANALYTIC APPROACH

J.4 Performance in this context consists of two elements — the number of units (pilots trained) and the quality of the units (i.e., proficiency of the pilots). The number of units may be the pilots trained annually (PTR), while the proficiency measure might include a gunnery score, navigation ability, etc.

J.5 The first step in specification of the model is to express the performance measure to be a function of several elements directly controllable by the decision-maker. The general form of this function is:

$$P = f(K, S, M, Q)$$

where P = performance

K = PTR

S = safety

M = personnel morale

Q = training quality.

Specification of the precise functional form, e.g.,

$$P = a_o + a_1 K + a_2 S + a_3 M + a_4 Q$$

or

$$P = a_o K^{a_1} S^{a_2} M^{a_3} Q^{a_4}$$

and the estimation of coefficients must be accomplished by CNATRA based on his expertise in this area.

J.6 The definition of the independent or explanatory variables is relatively straightforward. The quantity K is simply the PTR. The safety element is defined as the adequacy of facilities affecting flight activities. These facilities include physical elements such as runway length and width, parking apron space, etc.; and the more intangible "facility", air space. Morale can

be quantified through appropriate ratios such as student/instructor ratios, support personnel/aircraft ratios, etc. Quality of training can be measured by elements which directly impact on proficiency, e.g., student/instructor ratios, number of flying hours, aircraft utilization, etc.

J.7 The next step in the development of the model is to identify potential interrelations among the independent variables. This step is an important check to eliminate inconsistencies. For example, if the morale measures defined above increase, it may be necessary to increase some of the utilization measures to maintain an accurate representation of NATRACOM operations in the model. Table J.1 indicates how the measured elements of the independent variables interact. In actually estimating the coefficients and using the model, associated independent variables must be changed concurrently. PTR is somewhat unique in that for any change in this variable, virtually all the other elements would respond in the same direction, assuming no change in personnel or aircraft. Consequently, it is assumed in Table J.1 that PTR is held constant, and the other elements are simply traded off among themselves.

J.8 The last step in specifying the model is to determine how the independent variables should impact on performance. This prespecification, based on operational knowledge, is essential for comparison with actual estimates as a way of assessing the quality of the model, i.e., the prespecification and actual estimates should be in agreement. Table J.2 shows how each element of the independent variables might be expected to impact on performance.

WEIGHTING SYSTEM

J.9 Given a particular management climate (i.e., level of funding workload, availability of resources, etc.) the relative importance of quality of training, morale, and safety need to be expressed. W_i denotes the numerical value attached to each performance factor to reflect its relative weight or importance. Under each performance factor, the elements in turn must be assigned numerical values that reflect their importance. These values can be denoted by W_j. Finally, the relative importance of each element with respect to the phase of training must be indicated. This value can be denoted by W_k.

J.10 Establishing the rule that the numerical values can range from 0.0 to 1.0, the weight can be computed in several ways. For each element, either W_i or W_j can be used, but not both. W_k and W_i or W_j are then summed ≤ 1.0.

J.11 The system of weights might operate as follows. For each element there are Navy-specified requirements. A weight of 1.0 for a given element might imply that it should be 25 percent above the Navy requirement. For example, if required runway length is 8,000 ft, and it receives a weight of 1.0, the decision-maker believes that for complete safety the runway should be 10,000 ft. A zero weight would imply the decision-maker is willing to accept an element that is only 25 percent of the requirement, e.g., a 2,000 ft runway to be used only for touch and go landings. Obviously the assignment of weights to specific elements would have to be done very carefully.

TABLE J.1

POSSIBLE INTERACTION OF INDEPENDENT VARIABLES*

Elements, Column A	Elements, Column B								
	Safety				Morale		Quality		
	Runway length	Runway width	Air space density	Parking apron	Student/instructor ratio	Support personnel/aircraft	Student/instructor ratio	No. of flying hours	Aircraft utilization
Safety									
Runway length					o	o	o	o	o
Runway width					o	o	o	o	o
Air space density					o	o	o	o	+
Parking aprons					o	o	o	o	o
Morale									
Student/instructor ratio	o	o	o	o			+	o	o
Support personnel/aircraft ratio	o	o	o	o			o	o	+
Quality of Training									
Student/instructor ratio	o	o	o	o	+	o			
No. of flying hours	o	o	o	o	o	o			
Aircraft utilization	o	o	+	o	o	+			

* Plus and zero signs respectively indicate increase and no change in Column B element as a result of increase in Column A element.

TABLE J.2

HOW INDEPENDENT VARIABLES MIGHT AFFECT PERFORMANCE*

Independent Variables	Performance Variables	
	No. of Units	Quality of Units
PTR	+	o
Safety		
Runway length	o	+
Runway width	o	+
Air space density	o	+
Parking aprons	o	+
Morale		
Student/instructor ratio	+	—
Support personnel/aircraft ratio	o	+
Quality		
Student/instructor ratio	+	—
No. of flying hours/student	o	+
Aircraft utilization	+	—

* Plus, minus, and zero signs respectively indicate increase, decrease, or no change expected in performance variable as a result of increase in independent variable.

J.12 When the weights have been assigned, the decision-maker will have modified the requirements statement to explicitly allow for the safety elements in a way he feels will achieve maximum performance. A system of weighting factors need not be established immediately. Rather, it is desirable that the decision-maker (CNATRA) develop a weighting system which reflects his preferences, by selecting and testing various parameter values (levels of inputs) for each element and examining the associated performance and/or cost.

CONCLUSION

J.13 As noted, CNATRA must specify and estimate the model inputs. It is an analytic framework relatively straightforward in methodology, but it can only be implemented with data by the decision-maker. NATRACOM and, in particular, CNATRA, are already conducting performance analysis on an ad hoc basis. Development of a model will provide the rigorous definition of assumptions, variables, and methods, necessary to ensure consistency in the analysis process.

APPENDIX K

QUANTIFICATION PROBLEMS

K.1 The IFRS model developed in the Phase II study is a preliminary total systems model. The original task statement for Phase II was modified to develop a complete, albeit preliminary, total systems model to demonstrate that the IFRS management planning tool will in fact be an asset to CNATRA. The model's logic is correct, the model is operational, and it provides useful information to CNATRA at this time. However, certain refinements should be made in Phase III. The primary limitation of the preliminary model results from quantification problems associated with estimating

- NAS personnel requirements
- Certain facility requirements
- Base support O&M costs.

PERSONNEL REQUIREMENTS

K.2 Since the decision maker can vary the PTR, MIX, MODE, phase-to-base assignment, etc. of the IFRS model, the model must be able to estimate NAS personnel requirements for each training alternative at each NAS utilized. In reality, the requirements for each type of NAS personnel are estimated as a function of types of personnel supported. The total NAS personnel requirement is the sum of all the types, the result being an increasing step function.

K.3 To facilitate the development of the preliminary total systems model, the study team and NAVFAC agreed to assume that NAS personnel requirements are linearly related to the total personnel supported. Several Manning documents are available; in general, however, they are either projected base loadings or outdated base loadings. The best data source for current manpower information available to the study was an unofficial NATRACOM publication,"Facilities, Personnel, and Aircraft Summaries." Even though this is an unofficial publication, the study team and NAVFAC agreed to use it as the best available data base for the preliminary IFRS model with the intent to further investigate alternative Manning data bases in Phase III. In particular, the data contained in the individual LSR submissions will be incorporated into the analysis. The linear relationship was derived from regression analysis using the eight NATRACOM pilot training bases as the data base. Equations were determined for the four following categories.

- NAS officers
- NAS enlisted personnel
- Total NAS personnel (including civilian)
- NAS public works personnel.

K.4 The number of personnel in each category was estimated on the basis of the number of personnel of various types in the squadron, (i.e., phases), plus the number of tenants supported. From among the possible estimators, those which provided the best estimates of NAS personnel were chosen. The results of this selection appear in Table K.1. With the small sample size and distribution of the data points (see Figure K.1), statistical measures of the equations are of little value.1/ In Phase III additional analysis will be undertaken to correct the deficiencies in the personnel estimating equations. The present Phase II equations appear to give reasonable answers for the bases under consideration, although the precise quantity calculated for any one base may be higher or lower than actually required.

FACILITY REQUIREMENTS

K.5 Quantification problems were encountered in estimating the requirements for the following facilities:

- Fuel distribution lines
- Electrical distribution lines
- Potable water distribution lines
- Roads
- Automobile parking area.

1/ Each of these estimators has a .95 or higher correlation coefficient and the coefficients are significant with 90 percent confidence per the t test.

TABLE K.1

DEPENDENT VARIABLES AND ESTIMATORS

(Personnel*)

Dependent Variables	Estimators
Number of officers in NAS	Number of officers in squadrons and tenants
Number of enlisted men in NAS	Total personnel in squadrons and tenants
Total base population	Total personnel in squadrons and tenants
Public works personnel	Total personnel in squadrons and tenants

* The data for the eight NASs used for these estimators were obtained from NATRACOM, Facilities, Personnel, and Aircraft Summary, January 1969. The equations resulting from the regression analysis of these variables are contained in Appendix C.

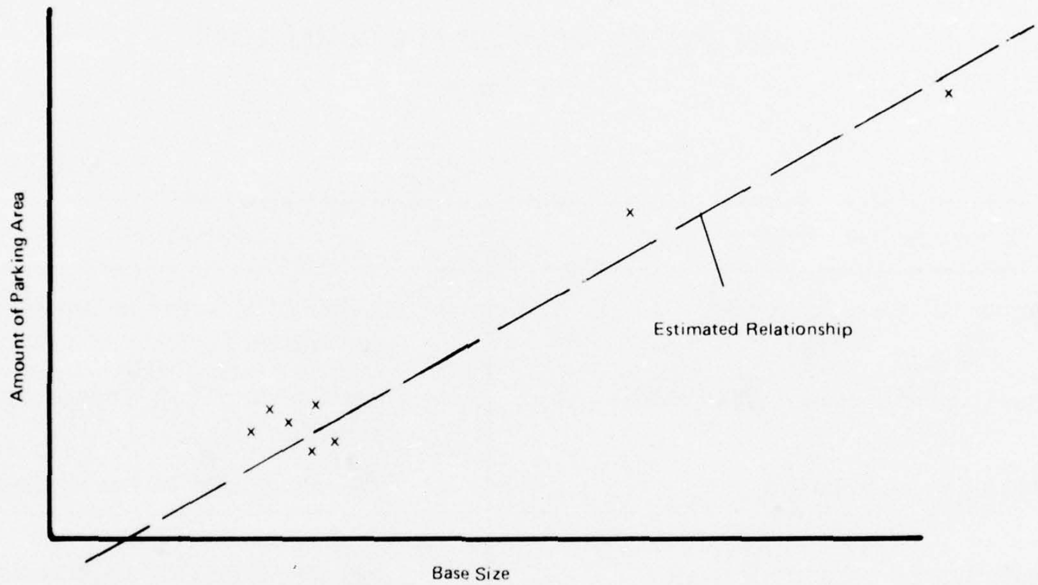


FIGURE K.1. UNEVEN DISTRIBUTION OF SAMPLE POINTS

K.6 Each of these facilities is calculated on an "as required" basis at a NAS and thus, generally, no amount appears on the base BFRL form. The study team and NAVFAC agreed that rather than drop these facility requirements, the preliminary IFRS model should include a means of estimating them, since they are included in the high cost items as defined earlier. The assumption was made that the amount of these facilities currently in existence at the eight bases under study was adequate. Furthermore, it was assumed that these requirements could be estimated for planning purposes with a linear relationship. Regression analyses were again used to develop the equations; the estimators employed appear in Table K.2. The distribution of data points and sample size are the same as for personnel and thus the statistical measures of these equations, although high, are of little value.[2] The values obtained from these equations appear to be reasonable for the completely new, phantom, base. It should be noted that unless significant changes occur in the base loading of the eight bases, the existing assets are probably adequate and these deficiencies probably should not be "built" by the model. Additional analysis will be undertaken in Phase III to improve the estimating equations.

BASE SUPPORT O&M COSTS

The base support O&M costs are also estimated by a regression equation since no better alternative could be developed for the preliminary model.[3] In Phase III, additional analysis of the RMS data will be undertaken so that a better estimator can be developed. However, for the preliminary IFRS model of Phase II, the Base Support costs for each NAS appear to be reasonable (some are higher than actual and others may be lower).

CONCLUSION

The intent of the Phase II IFRS was to develop a total systems planning tool that works and can be used by the decision maker—the Phase II model does both. However, in order to accomplish this intent, certain assumptions had to be made in order to develop the total model. As stated above, linear relations were assumed where necessary to facilitate the model development. These shortcomings will be studied further in Phase III to develop a more complete IFRS management planning tool.

2/ Each of the estimates has a .95 or higher correlation coefficient,and the coefficients are significant with 90 percent confidence per t test.

3/ The statistical measures of the equation were quite high (correlation coefficient .95 and 90 percent confidence that coefficients are significant), but the distribution of the data points and the sample size limit their value from a statistical viewpoint.

TABLE K. 2

DEPENDENT VARIABLES AND ESTIMATORS
(Facility Requirements*)

Dependent Variables	Estimators
Length of underground fuel distribution lines	Total personnel in squadrons and tenants
Length of electrical distribution lines	Total personnel in squadrons and tenants
Length of potable water distribution lines	Total personnel in squadrons and tenants/number of students
Miles of roads	Total enlisted men in squadrons and tenants
Automobile parking area	Total enlisted men in squadrons and tenants

* The equations resulting from the regression analysis of these variables are contained in Appendix D. The amount of existing facilities used for these estimators was obtained from Detailed Inventory of Naval Shore Facilities, NAVFAC P-164.

APPENDIX L

SENSITIVITY ANALYSIS

INTRODUCTION

L.1 The purpose of the sensitivity analysis is to determine how variations in input to the IFRS model affect the total systems cost (TSC). Specifically, the sensitivity analysis shows how these changes affect facility investment, aircraft investment, and O&M costs.[1/] Base values for all IFRS model inputs were established and are those discussed for the 2510 pilot training rate (PTR) and the present phase to base assignments, which are used throughout this report. The method employed is to vary one input at a time and hold all other inputs constant. On the basis of this analysis, the manager can readily identify the inputs that have a major impact on the TSC.

ELEMENTS OF SENSITIVITY ANALYSIS

L.2 Four major inputs to the IFRS model have a substantial effect on the TSC. Three of these are the control variables of PTR, MIX, and MODE, which are input to the LSR Generator. The fourth is the phase to base assignment schedule input to the Base Loading Submodel. A range of these key variables were input to the IFRS model and the resulting costs are displayed graphically in this appendix to enhance their usefulness to the decision maker.

Sensitivity to Pilot Training Rate

L.3 It is obvious that if significant variations in PTR occur, the TSC will also vary. Different PTRs were input to the IFRS model, ranging from a low of

---

1/ A detailed discussion of the TSC is contained in Appendix I.

2000 to a high of 3000, to identify the components of TSC affected and the magnitude of the change. All other factors were held constant for this analysis.[2] The results of this analysis appear in Figure L.1. The TSC varies from a low of approximately $330 million for a 2000 PTR to a high of approximately $710 million for a 3000 PTR, or more than 100 percent for a 50 percent increase in PTR. It is important to note how each of the three major cost categories varies with this PTR increase as shown in Figure L.2 and discussed below.

L.4 Facility Investment Costs (indicated in Figure L.2) are the outlays required to build the additional facilities needed to support pilot training programs at the indicated level.[3] The investments indicated in Figure L.2 are those required if existing standard and existing substandard facilities are assumed to be accepted. The investment required would be much larger if substandard facilities were not assumed to be accepted. The facility investment increases from about $32 million at a training level of 2000 pilots per year to over three times that amount for a 3000 PTR.

L.5 The greatest single investment cost category for additional facilities is family housing, which accounts for approximately 30 percent of all investment costs. Any changes in the family housing planning factors of the Facility Requirements Submodel (in particular, in the fraction of personnel requiring family housing) directly affects total investment costs. For example, the cost of building new housing is $21,500 per family. Thus, assuming 500 additional families require family housing at a base, the total incremental facility investment involved is approximately $11 million. A $5000 increase in building costs increases this investment by about 23 percent, or $2.5 million.

L.6 Of the three cost categories, aircraft investment costs are the most sensitive to changes in PTR. As indicated in Figure L.2, the total amount to be invested in aircraft varies from $70 million at a 2000 PTR to $330 million at a 3000 PTR, an increase of more than 450 percent. This investment is put toward the purchase of required aircraft and their initial provisioning. At the lower levels of pilot training, aircraft investment costs are for the TA-4J aircraft, of which (according to the assumptions made in the IFRS model) there is a large deficit, and the TH-1L, which is now being purchased for the first time. For higher level pilot training it becomes necessary to buy aircraft of all types, and thus aircraft investment costs increase sharply as pilot training levels approach 3000 per year. Note that, as in the case of facility investment costs, aircraft investment costs are also one-time cash outlays. Thus, if aircraft are bought to meet deficits in one year, and pilot training rates remain constant or decrease the next year, no additional aircraft need to be purchased except to replace aircraft attrites.

---

[2] The MIX used in this analysis is: Jet, 38.5 percent; Prop, 37.8 percent; and Helo, 23.7 percent.

[3] This is a one-time investment, and if made in a year, it would not have to be repeated in following years assuming the same or a lower PTR were maintained.

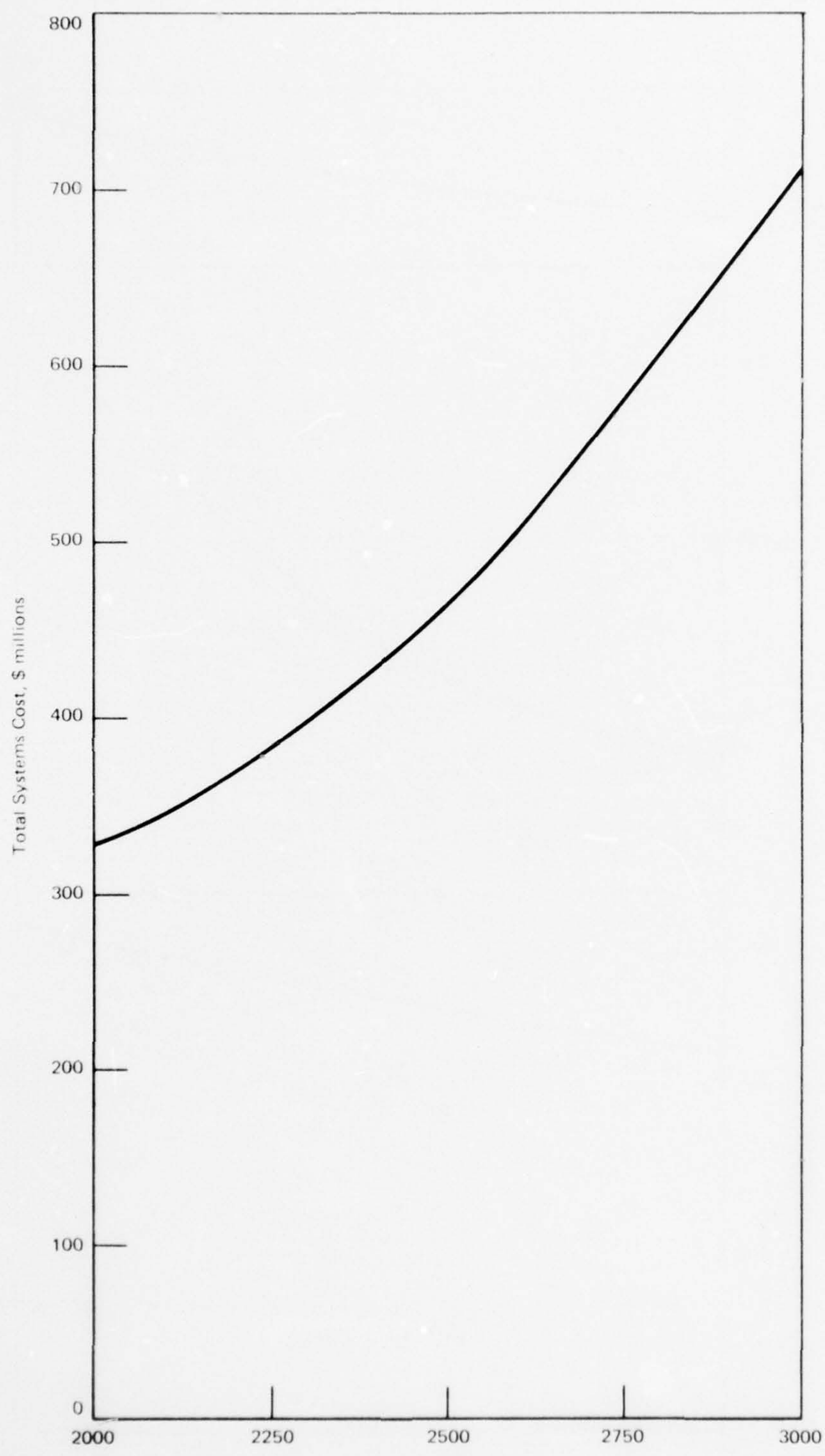


FIGURE L.1. SENSITIVITY OF TOTAL SYSTEMS COST TO PILOT TRAINING RATE

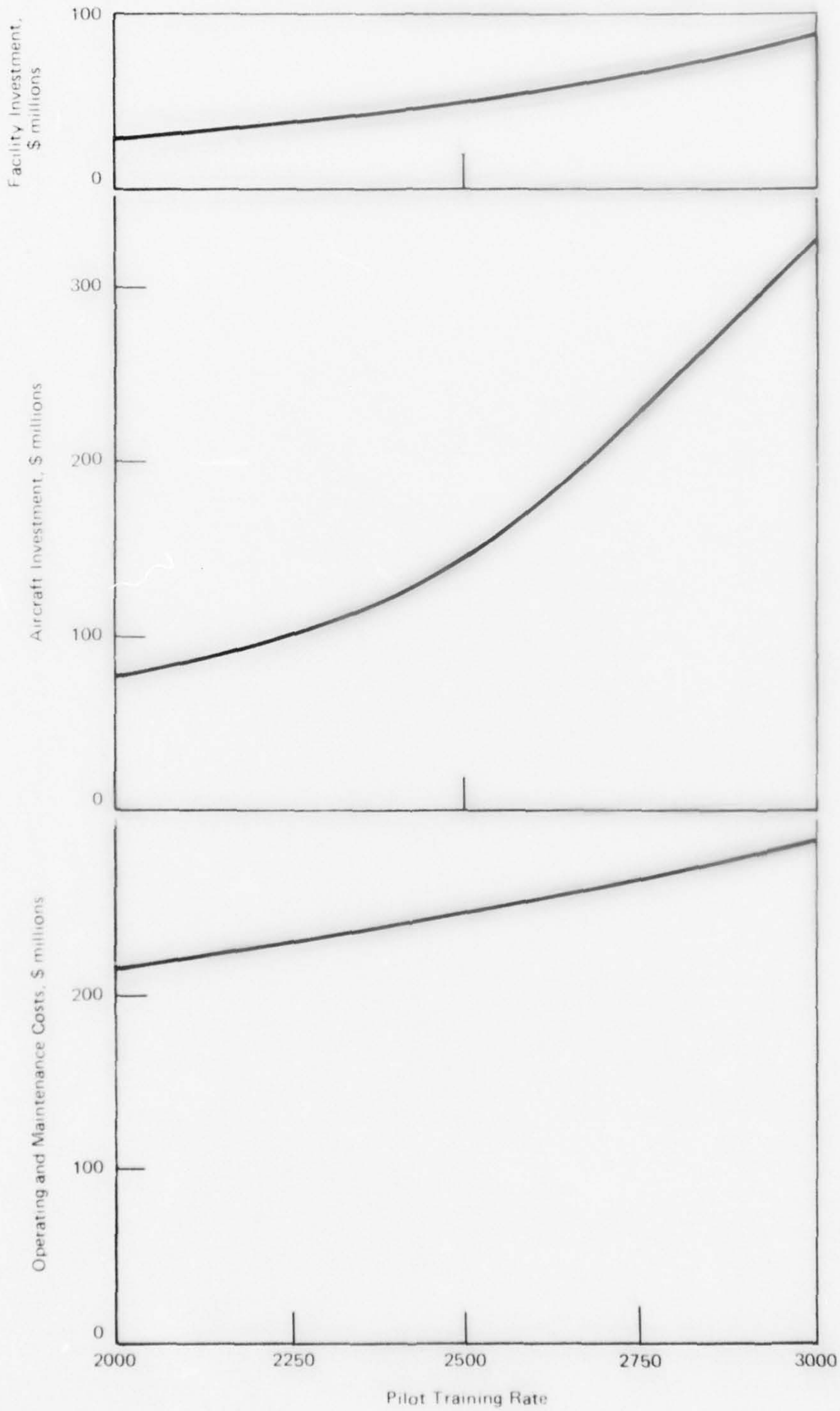


FIGURE L.2. SENSITIVITY OF INVESTMENT AND OPERATING AND MAINTENANCE COSTS TO PILOT TRAINING RATE

L.7 Operating and maintenance costs include the annual spending for military pay and allowances, aircraft fuel, aircraft support, base support, and fixed costs and are the largest single cost category, as shown in Figure L.2. Total annual expenditures in this category vary from $226 million to $297 million, representing roughly 40 to 70 percent of the TSC. The O&M cost per pilot trained is about $113,000 at the 2000 PTR level and decreases to $99,000 per pilot at the 3000 PTR level. Almost 70 percent of the O&M costs are for military pay and allowances for students, training phase personnel, and NAS personnel. Thus, as PTR increases, O&M costs increase primarily as a result of larger personnel requirements. About 12 percent of O&M costs are for aircraft fuel and about 12 percent for base support costs, with the remaining 6 percent for aircraft support costs.[4/]

Sensitivity to MODE

L.8 To illustrate how changes in MODE affect TSC, three key variables of the MODE — phase duration in weeks, aircraft flight hours per student output, and instructor hours per student output — were varied linearly for all phases in the pipeline. The three variables were reduced by 10 and 20 percent and increased by 10 and 20 percent with all other variables held constant. Current phase to base assignments were retained and a 2510 PTR was used. The results of this analysis appear in Figures L.3 and L.4. Both figures are calibrated in percent of standard MODE, i.e., the percent that these three variables were varied from the standard values.

L.9 The results of this test are the same as those obtained by varying the PTR, as discussed previously. Decreasing PTR by 20 percent has the same effect on the LSR Generator output (i.e., average student load,[5/] personnel requirements, aircraft requirements, and fuel consumption) used as input to the TSC Submodel as decreasing these three variables by 20 percent and holding the PTR constant. The reason for this is that these three variables and the PTR affect the LSR calculations in the same way. Thus an incremental change in the PTR produces the same result in the LSR Generator output as a similar change in the three variables. For example, the reduction of the present MODE by 20 percent to .80 has the same effect on TSC as a reduction in PTR from 2500 to 2000. In either case, TSC decreases from $460 million to $330 million.

L.10 The factors producing the costs shown in Figure L.4 when MODE is varied are identical to those which exert an effect when PTR is varied. Thus,

---

4/ As noted in Appendix I, the factors for aircraft support costs in the model do not include all O&M factors due to the classified nature of the NAVAIRSYSCOM data.

5/ Naturally, student inputs and outputs are different. The average student load does not change and is the output used in subsequent calculations.

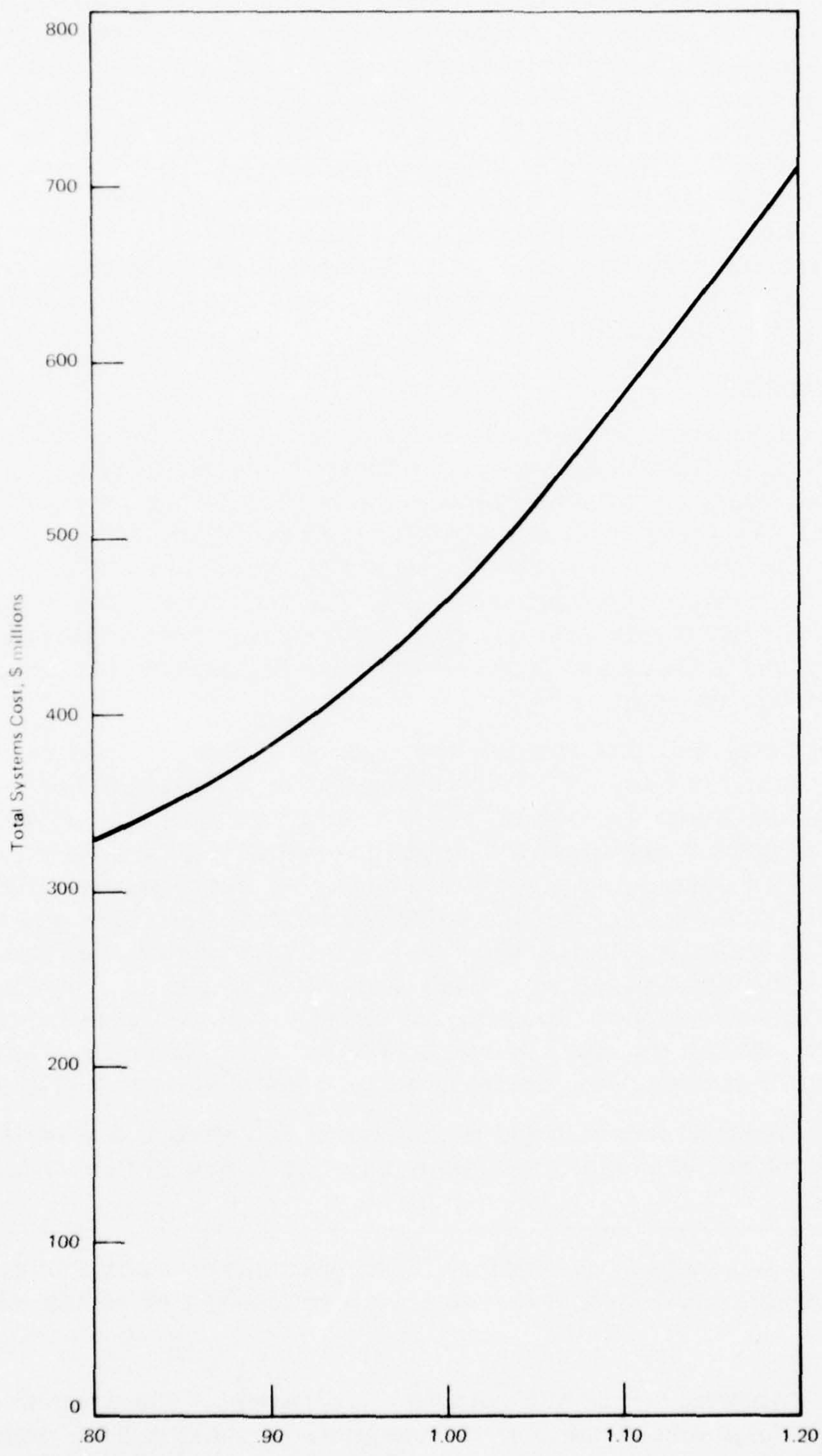


FIGURE L.3. SENSITIVITY OF TOTAL SYSTEMS COST TO MODE

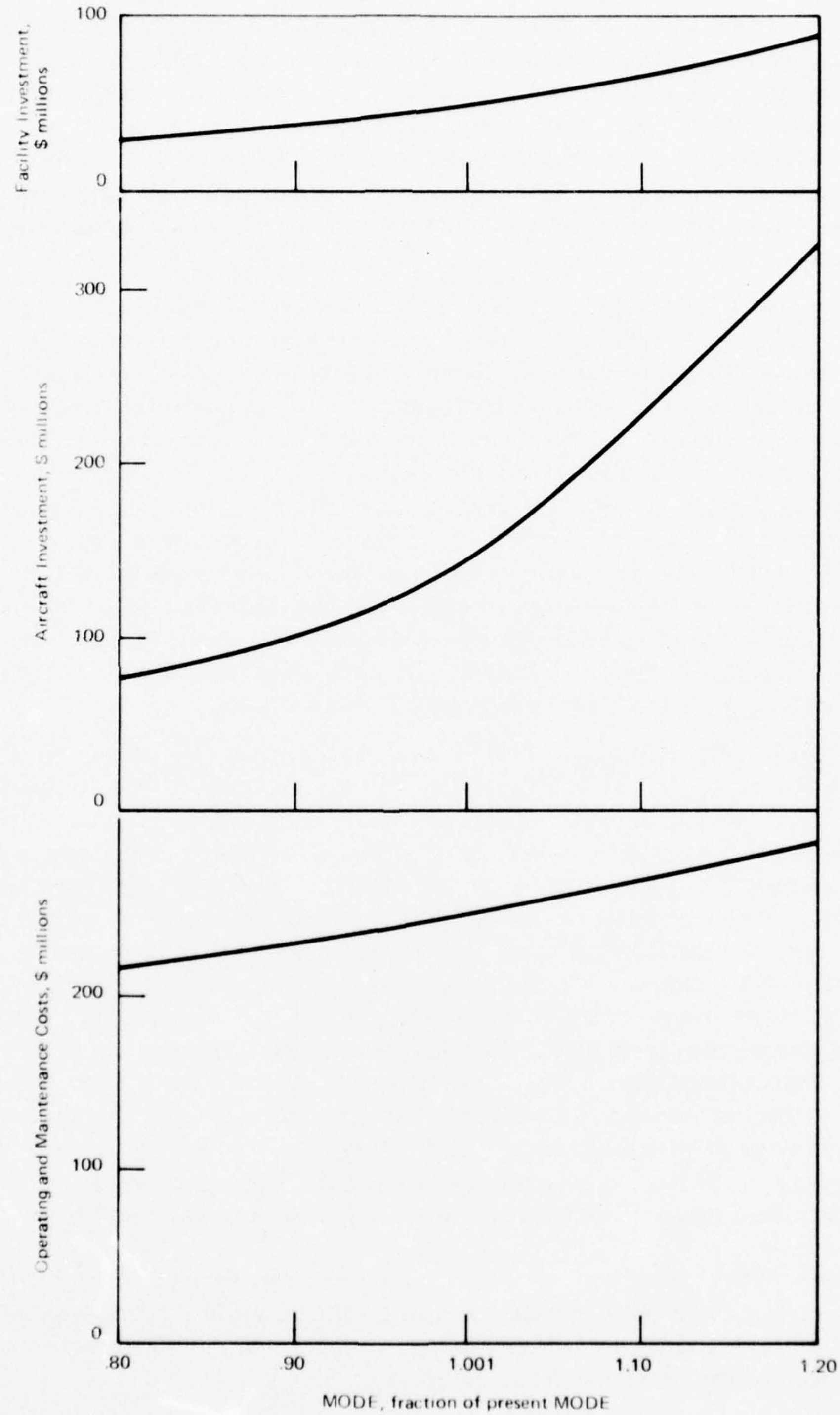


FIGURE L.4. SENSITIVITY OF INVESTMENT AND OPERATING AND MAINTENANCE COSTS TO MODE

housing investment, military pay and allowances, and TA-4J and TH-1L aircraft investments are a major share of the TSC indicated in Figure L.3.

Sensitivity to MIX

L.11 The third major input into the LSR Generator, which substantially influences TSC, is MIX, the distribution of pilots among the jet, prop, and helo training programs. On the basis of a 2510 PTR, current phase to base assignment, and current MODE, the MIX was varied over a small range[6] by holding one type of pilot output constant and varying the other two. In each case, it was assumed that the total number of students remained the same and only the type of student was varied. The sensitivity of TSC to MIX is indicated in select cases in Figure L.5.

L.12 Prop-Helo MIX Change. Figure L.5 indicates the effect of changing the relative MIX of prop and helo pilots while the number of jet trainees remains constant. As indicated in the first graph in Figure L.5, TSC increases rather steeply with an increasing prop student output, principally because of sharply increased aircraft investment costs (mainly for TS-2A aircraft). Conversely, aircraft investments decrease with increasing helo student output, because fewer TS-2A aircraft are needed, and the high initial costs saved more than offset the increased cost of the TH-1L aircraft. The facility investment costs shown in Figure L.5 show a slight decrease with increasing helo student output. O&M costs also remain relatively stable, reflecting the fact that total miliary personnel, and thereby pay and allowances, do not vary appreciably with changing prop and helo student output. However, it should be noted that the mix of aircraft mechanics will change as aircraft MIX changes.

L.13 Jet-Helo MIX Change. Figure L.5 also shows the effect on TSC of changing the relative MIX of jet and helo student outputs while keeping the prop output constant. As jet output increases, TSC rapidly rises, principally because of greatly increased aircraft investment costs. However, O&M costs also increase appreciably with the increased jet output. Three factors produce this effect. First, a greater number of enlisted men are required to maintain jet aircraft than helo aircraft, and therefore total personnel requirements increase with increasing jet output. Second, the total period required to train jet pilots is about 15 percent longer than the training period for helo pilots, further increasing personnel requirements. Finally, jet aircraft operating costs are much greater than helo operating costs. Facility investment costs also increase to some extent with increasing jet output, primarily because of the increased investment needs for family housing at NAS Meridian, which is already deficient in family housing. Thus, as the number of jet trainees increases, NAS Meridian, which supports two phases of jet training, requires a great deal more family

---

[6] MIX was varied only over a small range because wide variations would result in irregular base loading. If MIX were actually varied in practice, phases would undoubtedly be reassigned to bases.

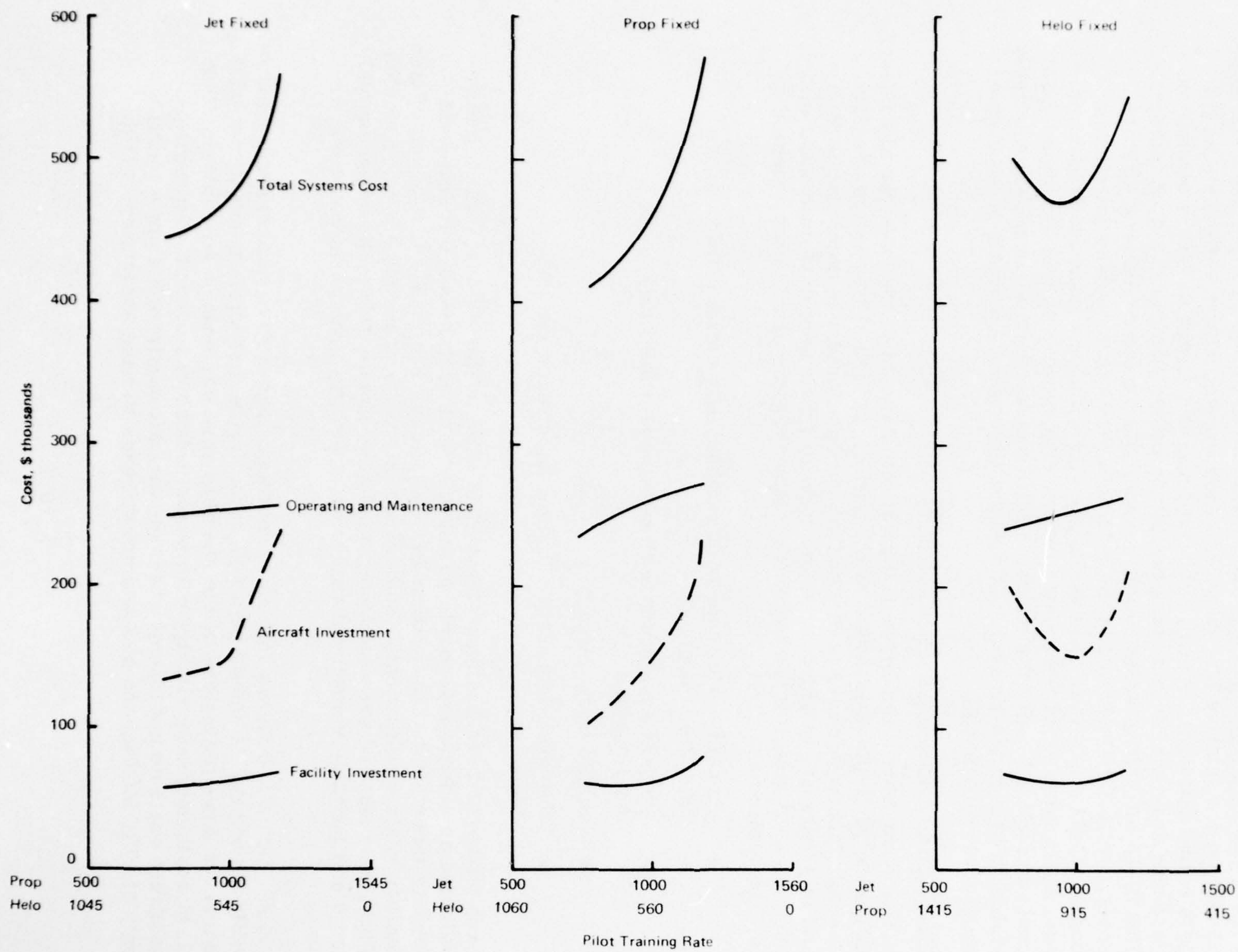


FIGURE L.5. SENSITIVITY TO MIX

housing to accommodate the influx of families of jet students and additional support personnel.

L.14 Jet-Prop MIX Change. The last graph in Figure L.5 indicates the effect of varying the relative MIX of jet and prop student output while keeping the helo output constant. Again, the most important factor in TSC is aircraft investment cost, which increases rapidly as either jet or prop output increases. The TS-2A aircraft is again mainly responsible for increased prop aircraft costs, while TA-4J aircraft is the principle factor in increased jet aircraft costs. O&M costs tend to increase slightly with increasing jet student output, again because of the greater personnel requirements and the higher O&M costs associated with jet aircraft. Facility investment costs remain relatively stable, although the present MIX appears to produce a slightly smaller investment cost requirement.

Sensitivity to Phase to Base Assignment

L.15 One other major input change at the disposal of the user can significantly influence TSC: the assignment of the various phases of training to specific bases. This assignment is one of the principle factors in determining TSC, and in particular, in determining the facility investment cost component of TSC. Four different phase to base assignment alternatives were selected for this analysis:

- Present assignment with standard and substandard facilities accepted
- Present assignment with substandard facilities not accepted
- Single base concept
- Present assignment with new base replacing NAS Meridian.

Each phase-to-base assignment schedule used in this analysis was carefully selected as being a reasonable possibility leading to reasonably low-cost facility investments. If these selections had not been made judiciously, large facility costs could be obtained because of base overloading and underloading. Thus, care must be exercised when assigning phases to bases, or excessively large and probably unrealistic estimates of facility investment costs may result.

L.16 Figure L.6 shows TSC as a function of phase to base assignment and facility condition. It should be noted in the figure that aircraft investment cost remains the same regardless of the phase to base assignment schedule and that O&M costs vary only slightly with phase to base assignment. Aircraft investment costs do not change, because aircraft requirements are a function only of PTR, MODE, and MIX and not of phase to base assignment. O&M

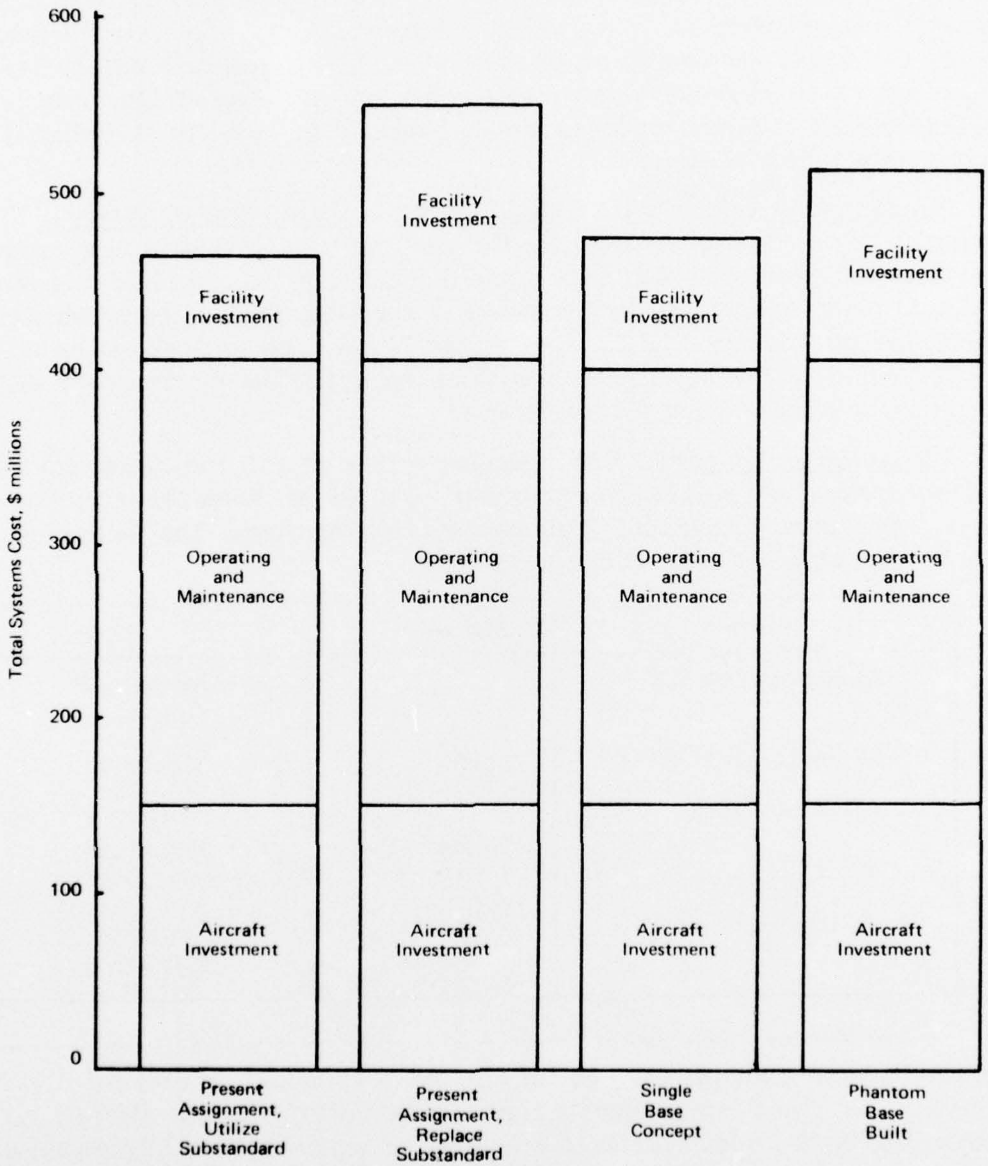


FIGURE L.6. TOTAL SYSTEMS COST AS A FUNCTION OF PHASE ASSIGNMENT AND FACILITY CONDITION

costs vary only slightly because the major portion of these costs are personnel expenses and aircraft O&M and fuel costs, which are insensitive to changes in base assignment. Therefore, the only component of TSC which does change substantially with phase to base assignments is facility investment cost.

L.17 Present Assignment With Standard and Substandard Facilities Accepted. The first bar in Figure L.6 shows the TSC for the present phase to base assignment schedule (see Appendix C) in which substandard facilities are assumed to be used by the base. As indicated in the figure, TSC is approximately $465 million, of which O&M costs and aircraft costs are the largest elements, totaling approximately $405 million, or 86 percent of the TSC. Facility investment costs are approximately $60 million.

L.18 Present Assignment With Substandard Facilities Not Accepted. The second bar in Figure L.6 gives TSC for the same current phase to base assignment but with the provision that substandard facilities are not used and will be replaced with new facilities. As indicated in the figure, facility investment costs increase by a factor of 2.3, i.e., from $60 million to $140 million. Thus, $80 million would be the approximate cost of replacing the substandard facilities at all eight bases conducting pilot training.

L.19 Single Base Concept. The third bar in Figure L.6 indicates the TSC to be expected for the "single base concept"7/, in which students would be stationed at one base throughout their entire pilot training. The following allocation of terminal phases to bases is made.

Phase	Percent	Base
07 Advanced Jet (TF-9J)	50	Kingsville
	50	Chase
08 Advanced Jet (TA-4J)	100	Meridian
11 Advanced Prop	33	Corpus Christi
	34	Pensacola
	33	Whiting
14 Helo Advanced	50	Saufley
	50	Ellyson

7/ The single base concept used in this example is based on present syllabus, pipeline, etc., and consequently there are several different aircraft types assigned to each base. If a true single base concept were to be studied, it is likely that one or possibly two different aircraft types would be required at each base and that syllabi would be revised to account for the aircraft of one or a few types used throughout most phases.

L.20 The nonterminal phases of training are allocated to the eight bases in such a manner that a pilot trainee would go through all phases of training at the base where he started training. For example, a pilot intended to graduate from 07 Adv Jet would be stationed at either Kingsville or Chase for his entire training period. Similiarly, a pilot trainee graduating from 08 Adv Jet would have received his training entirely at Meridian and would have passed through all the following phases at that base: Primary; AOC (if necessary); Flight Systems; Basic Jet A; Basic Jet B; Basic Jet CQ; and Advanced Jet.

L.21 The effect that this phase to base assignment would have on TSC is shown in Figure L.6. As previously noted, aircraft investment and O&M costs do not change appreciably from other phase to base assignment schedules. However, most interestingly, the facility investment cost for the single base training is not substantially larger than that for the present phase to base assignment schedule (represented by the first bar in Figure L.6 since substandard facilities are not to be replaced). The increase in cost is only $10 million, from $60 million to $70 million. Most of this increase is due to family housing construction required at Meridian to make up for the rather heavy loading of that base. Thus, it can be inferred that if the single base concept, as defined for this analysis, were implemented, and the phase to base assignments were carefully made, TSC for the single base assignments would not be significantly different from the TSC generated by the existing assignments.

L.22 Present Assignment With New Base Replacing NAS Meridian. The fourth and last phase to base assignment shown in Figure L.6 is identical to the first assignment shown except for one change: both phases of training being conducted at Meridian are assigned to NAS Phantom, a new base assumed to be built to replace Meridian, with new construction for all facilities at NAS Phantom. As indicated in the figure, if this change were implemented, facility investment costs would increase to approximately $100 million from the previous $60 million. This would be the approximate estimated change in facilities costs[8] if a new base were built from the ground up to replace Meridian.

SUMMARY OF SENSITIVITY ANALYSIS

L.23 This appendix describes the effect on TSC of changes in four types of inputs to the IFRS model. A summary of the sensitivity of the facility investment, aircraft investment, and O&M costs as a function of the inputs varied appears in Table L.1. All three cost categories are highly sensitive to changes in PTR and MODE when all other inputs are held constant. The principle conclusion that may be drawn concerning the sensitivity of TSC to changes in MIX is that aircraft investment costs are extremely sensitive to MIX variations, the reason being that new aircraft are expensive, and that once existing aircraft are fully utilized, new aircraft must be procured. Facility costs, on the other hand, are the most sensitive to changes in phase to base assignments.

8/ Those included in the IFRS model.

L.24 The sensitivity analyses shown in this appendix are some of many that can be conducted with the use of the IFRS model. The manager can use the IFRS model to determine which planning factors are sensitive to TSC and how changes in planning factors affect TSC. For example, the manager can see how decreasing flight hours per student, decreasing runway width, increasing parking apron allowances, etc. affect TSC. Answers to these and many more types of questions can be obtained from the IFRS model by exercising it several times. The manager should use the model to evaluate his planning factors to ensure that he has the best data base available at this time.

TABLE L.1

SENSITIVITY ANALYSIS SUMMARY

Input	Cost Category		
	Facility Investment	Aircraft Investment	O&M
PTR	High	High	High
MODE	High	High	High
MIX			
Jet fixed	Low	High	Low
Prop fixed	Low	High	Low
Helo fixed	Low	High	Low
Phase to base assignment	High	Insensitive	Low

APPENDIX M

BIBLIOGRAPHY

Airborne Instruments Laboratory, Airport Capacity—A Handbook for Analyzing Airport Designs to Determine Practical Movement Rates and Aircraft Operating Costs, Long Island, New York, June 1963.

Bernard Johnson Engineers, Inc., Consulting Engineers-Planners, Master Plan, Naval Air Station, Corpus Christi, Texas, Parts 1, 2, and 3, for the Naval Facilities Engineering Command, Gulf Division, December 1968.

Bureau of Aeronautics, "The Naval Aircraft Maintenance Program," NAVAERINST 4700.2, October 1967.

________, Planning Standards, U.S. Naval Aeronautical Shore Facilities, NAVAER 00-100-505, 1966.

________, Programming Guide, NAVAER 100-504, March 1958.

________, Technical Planning Manual, NAVAER 100-53, March 1958.

Bureau of Yards and Docks, Category Codes for Classifying Real Property Inventory, NAVDOCKS P-72, April 1966.

________, Design Manuals:

DM-3	Mechanical Engineering
DM-4	Electrical Engineering
DM-10	Cost Data for Military Construction, June 1961
DM-21	Airfield Pavements
DM-22	Liquid Fueling & Dispensing Facilities
DM-23	Communication Navigation Aids and Airfield Lighting
DM-24	Land Operational Facilities

DM-27 Training Facilities
DM-35 Family Housing
DM-36 Troop Housing

________, "General Development Maps,"Existing and Planned Pre-M-Day Key Map for the following bases:

	Approved BUDOCKS	Updated to
NAAS Chase Field	2/16/62	11/30/65
NAS Corpus Christi	2/19/62	12/7/65
NAAS Whiting Field	10/30/62	1/18/68
NAS Pensacola, Fla	8/28/62	9/23/66
NAAS Saufley	3/21/62	12/12/67

________, "Host/Tenant Participation in Shore Facilities Planning," undated.

________, "Host/Tenant Real Estate Agreements," BUDOCKINST 11011.51, 7 September 1965.

________, Real Property Inventory Instructions for Preparation and Distribution of Property Record Cards, NAVDOCKS P-78, August 1965.

Commander, Naval Supply Systems Command, "Review of FY'71 MILCON Project P-372-NAS Pensacola and FY'71 MILCON Project P-022-NAAS Saufley Field Capacity Planning Criteria for Enlisted Men's Food Service Facilities," letter to Commander, Naval Facilities Engineering Command (Fac 203A), 1 May 1969.

Department of Defense, The Military Construction Cost Review Guide, Fiscal Year 1971, Washington, D.C.

________, Office of the Assistant Secretary of Defense (Installations and Logistics), DOD Construction Criteria Manual, DOD Instruction 4270.1, 17 November 1967.

Department of the Air Force, Military Construction Pricing Guide, AFP 88-16, 29 May 1969.

Department of the Navy, FY69 Program Cost Estimates, Military Construction Program, Washington, D.C., 26 September 1968.

________, FY70 Program Cost Estimates, Military Construction Program, Washington, D.C., 25 February 1969.

________, MCON Program Objectives by Area/Activity, Report No. 1348-Sequence 103A, March 1969.

________, "Military Construction Authorization-Appropriation FY 1970, Justification Data Submitted to Congress," 14 April 1969.

________, Military Construction Program-FY 1970, Summary of Facility Classes, Washington, D.C.

Engineering News Record, March 1969.

General Electric Company, Information Service Department, Command System, Mark II Time-Sharing Service, Reference Manual, Revised June 1969.

_________, _________, FORTRAN Language, Mark II Time-Sharing Service, Preliminary Reference Manual, Revised April 1969.

Groll, Beach, and Associates, Bellante and Clauss, C. Warren Began and Associates, Programming Guide, U.S. Naval Aeronautical Shore Facilities, NAVAER 00-100-504, report prepared under Navy Bureau of Aeronautics Contract No. S67-453F, March 1968.

Heilbron, Richard, et al., Integrated Facilities Requirements Study, Phase I—Development of the Two-Model System, ORI TR 520, 5 December 1968.

Hirsh, F.W., "Determination of Housing Requirements and Project Composition, DOD Form 1378, 15 July 1968.

_________, "Narrative on Family Housing," DOD Form 1379, 31 January 1968.

_________, Tabulation of Family Housing Survey—DOD Form 1377, for NAS Corpus Christi; Naval Complex, Pensacola; NAS Whiting Field; NAS Meridian, NAS Kingsville; NAS Chase Field; 31 January 1968.

Hooton, E.N., et al., Operational Evaluation of Airport Runway Design and Capacity—A Study of Methods and Techniques, Airborne Instruments Laboratory, Long Island, New York, January 1963.

Military Construction Line Item Data, DOD Form 1391 and PCE data for various category codes and NASs, FY 1967-1970.

Naval Air Systems Command, "NAAS Chase Field, Additional Jet Fuel Storage," AIR-4243C:TWJ, 15 May 1968.

Naval Air Training Command, CNATRA Mission, a series of photographs pictorially describing the organization and mission of CNATRA.

_________, Facilities, Personnel and Aircraft Summary, January 1969

_________, "FY67 Military Construction Program," 26 February 1968.

_________, "Military Construction Line Item Data," DD Form 1391 and instructions, completed for FY66, FY67, FY68, and FY69, completed by:

Naval Air Station, Corpus Christi, Texas
Naval Air Station, Pensacola, Florida
Naval Auxiliary Air Station, Chase Field, Texas
Naval Auxiliary Air Station, Ellyson Field, Florida
Naval Auxiliary Air Station, Kingsville, Texas
Naval Auxiliary Air Station, Meridian, Mississippi
Naval Auxiliary Air Station, Saufley Field, Florida
Naval Auxiliary Air Station, Whiting Field, Florida

__ ______, Pilot Training Program Attrition Study Covering Fiscal Years 1965, 1966, 1967, and 1968.

Naval Facilities Engineering Command, "Bachelor Enlisted Men's Housing Design Guidance and Definitives," NAVFACINST 11012.114, 21 January 1969.

_________, Definitive Designs for Naval Shore Facilities, NAVDOCKS P-272, Part 1, Vols. 1 and 2, Parts 2 and 3, July 1962.

_________, Detailed Inventory of Naval Shore Facilities, NAVFAC P-164, 30 June 1968, Vols. 1, 2, and 3.

_________, "Determination of Bachelor Housing Requirements," DD Form 1657 (1 March 1968), completed by:

Naval Air Station, Dallas, Texas
Naval Air Station, Glynco, Georgia
Naval Auxiliary Air Station, Ellyson Field, Florida
Naval Auxiliary Air Station, Kingsville, Texas
Naval Auxiliary Air Station, Meridian, Mississippi
Naval Auxiliary Air Station, Saufley Field, Florida
Naval Hospital, Naval Air Station, Corpus Christi, Texas

_________, Facility Planning Factors for Naval Shore Activities, NAVFAC P-80, January 1967.

_________, List of Program Objectives Reports With Explanatory Notes, 1 April 1969, Enclosure 4.

_________, "Program Cost Estimates for Military Construction Line Items," NAVFACINST 1101.14I, 17 March 1969.

_________, "Shore Facilities Planning," NAVFACINST 11010.44, 26 February 1968.

_________, "Shore Facilities Planning," NAVFACINST 11010.44, Ch. 1, 26 June 1968.

_________, "Shore Installations and Facilities Planning—BFRL," NAVFACNOTE 11010, 10 April 1969.

_________, Gulf Division, "General Development Map," Existing and Planned Pre-M-Day for the following base:

NAAS Kingsville — Updated 12/6/67

_________, _________, "General Development Map," Existing and Planned Pre-M-Day, NAVFACENCOM for the following bases:

	Submitted	Updated to
NAAS Ellyson	7/9/62	8/5/68
NAS Meridian	9/5/67	

________, ________, Master Plan (Preliminary), NAS Chase Field, Beeville, Texas, December 1968.

Navy Staff Offices, "Financial Management of Resources," NAVSO P-3006, Change 1 only.

Office of the Assistant Secretary of Defense, Navy Undergraduate Pilot Training Base Capacity Study, 28 June 1968.

________, United States Air Force Undergraduate Pilot Training Base Capacity Study, Part I: Model Description, 12 February 1968.

Office of the Chief of Naval Air Advanced Training, "Master Academic Training Syllabus, promulgation of," CNAVANTRAINST 1542.1A, 4 March 1968.

________, "Syllabus, Flight, Advanced Prop Pilot Training," CNAVANTRAINST 1542.4A, 24 March 1969.

________, "TF/TAF-9J Advanced Jet Syllabi; promulgation of," CNAVANTRAINST 1542.6A, 8 December 1967.

Office of the Chief of Naval Air Basic Training, "Basic Academic Training Syllabus," CNABATRAINST 1542.63F, 6 January 1969.

________, "Memorandum of Agreement With Commander 32nd NORAD Division for Identifying Aircraft of the Naval Air Basic Training Command Operating Within the Gulf of Mexico Air Defense Identification Zone," CNABATRAINST 5451.1M (CH-2), 18 April 1968.

________, "Outlying Fields and Training Areas for NABATRACOM (Pensacola Area) Activities, assignment of," CNABATRAINST 5451.1M, 1 November 1966.

________, "Syllabus, Flight and Flight Support, Basic Carrier Qualification Stage, T-28," CNABATRAINST 1542.64A, 13 June 1967.

________, "Syllabus, Flight and Flight Support, Basic Training (Jet), Phase A, T-2A," CNABATRAINST 1542.68B, 7 March 1968.

________, "Syllabus, Flight and Flight Support, Basic Training (Jet), Phase B, T-2B," CNABATRAINST 1542.79A, 7 March 1968.

________, "Syllabus, Flight and Flight Support, Basic Training Phase (Prop), T-28," CNABATRAINST 1542.55A, 20 December 1967.

________, "Syllabus, Flight and Flight Support, Helicopter Training," CNABATRAINST 1542.30B, 25 January 1967.

________," Syllabus, Flight and Flight Support, Pre-Helicopter Phase T-28," CNABATRAINST 1540.53F, 19 April 1965.

________, "Syllabus, Flight and Flight Support, Primary Phase, T-34B," CNABATRAINST 1542.54A, 11 February 1969.

________, "Training Syllabus, Naval School, Aviation Officer Candidate, Naval Aviation Schools Command, Pensacola, Florida," CNABATRAINST 1542.66F, 9 February 1968.

________, "Training Syllabus, Naval School, Flight Preparation, Naval Aviation Schools Command, Pensacola," CNABATRAINST 1542.65D, 9 February 1968.

________, "Weekly Aviation Statistical Report," CNABATRA 3760/11, revised September 1966.

________, "Weekly Student Status Report," CNABATRA 3760/12, revised September 1968.

Office of the Chief of Naval Air Training, "Academic Instructor Requirements, computing of," CNATRAINST 5311.4, 1 April 1964.

________, "Aircraft and Instructor Hour Breakout (Sheets)."

________, "Academic Training Syllabi Outline, Pilot Training Program, Naval Air Training Command," CNATRA P1542/3, revised March 1968.

________, "CNATRA Military Construction Review Board," CNATRAINST 11010.2B, 2 April 1969.

________, "Forwarding of U.S. Navy Fuel Consumption Factors," 4 September 1968.

________, "Planned Monthly Factors Based on Expected Flyable Weather, FY 1969," CNATRA-GEN-5000/3.

________, "(Profile of) Administrative Supervisory Officers Required," 20 October 1966.

________, <u>RMS for Operations, Handbook</u>, CNATRA P7000-1, revised March 1969.

Office of the Chief of Naval Operations, "BFRL for NAS Corpus Christi, Texas, information concerning," 22 September 1967.

________, "Catalog of Naval Shore Facilities," OPNAV P09B3-105, 15 October 1968.

________, "Evaluation of Existing Shore Facilities Assets," OPNAV Forms 11000-2, and 11000-2A, completed by:

NAS Meridian	10 December 1968
NAS Kingsville	19 March 1965 and 16 March 1967, revised 5 December 1967
NAS Corpus Christi	7 August 1968
NAS Saufley Field	31 October 1967
NAS Ellyson Field	12 March 1965, revised 16 September 1965

NAS Pensacola	17 March 1965
NAS Whiting Field	8 January 1968
NAS Meridian	6 December 1968
NAS Chase Field	14 March 1967, revised 6 December 1967.

________, "Habitability and Occupancy Criteria for Bachelor Housing," OPNAV-INST 11012.2A, 28 September 1967.

________, "Logistic Support Requirements System," OPNAVINST 4000.72 and 4000.72A, 24 July 1967 and Change Transmittal 1, 22 September 1967.

________, "Manpower Authorizations, form and procedures for requesting changes to," OPNAVINST 1000.16A, 3 February 1969.

________, Navy Program Factors (U), OPNAV-90P-02, Group 4,rev. 1 January 1970, CONFIDENTIAL.

________, "Shore Activity Basic Facility Requirements," OPNAV Form 11000-1, completed by:

NAAS Ellyson Field	31 January 1968
NAAS Chase Field	March 1968
NAS Kingsville	3 December 1968
NAAS Saufley Field	1 December 1967
NAS Pensacola	31 May 1967
NAS Corpus Christi	1 February 1967
NAAS Whiting Field	November 1967
NAAS Meridian	31 June 1965

________, "Shore Installations and Facilities Planning and Programming," OPNAV-INST 11010.1E, 7 November 1967.

Office of the Chief of Naval Operations, Staffing Criteria Manual for Activities Ashore, OPNAVINST 5310.51

Office of the Comptroller, "Changes in Funding Responsibility, procedures Regarding," NAVCOMPTINST 7040.7B.

________, "Financial Responsibility for Facilities and Services Furnished to a Tenant Activity or Unit," NAVCOMPTINST 7200.29B, 5 March 1968.

________, "Military Personnel Expenses, control of," NAVCOMPTINST 722.47, 15 June 1968.

________, Navy Comptroller Manual, NAVSO P-100-2-180, Vol. 2, Change 180.

Office of the Secretary of the Navy, "Definitions of Expenses and Investment Costs," SECNAVINST 7040.6A, 26 July 1967.

Resource Management System, Computer printouts for January-April of FY 1969, including NAVCOMPT, CNATRA, CNABATRA, CNAVANTRA, eight NASs, and Training Squadrons.

Stewart, R.M., Planning Factors for Pilot Training Derivation and Use, prepared for the Naval Air Training Command, undated.

Taylor, John W. (ed.), Janes All the World's Aircraft, Sampson Low, Marston and Company, Ltd., London.

"Tentative Methods of Measuring Exploration Loss from Petroleum Tanks and Transportation Equipment," American Petroleum Institute Bulletin, July 1957.

United States Congress, House of Representatives, "To Authorize Certain Construction of Military Installations," HR12171, 16 June 1969.

Washington Daily News, 1969 World Almanac, Washington, D.C.